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ABSTRACT

Electronic computers have caused numerous changes in medical health sciences, and the abilities of the computer are so great that much research thinking, administrative planning, and other medical activities are controlled largely by what the machine can do. However, developments in computer technology have occurred in different areas with little exchange of information. The report provides data for counselors, students, and employment agency personnel on technological developments in medical sciences and includes information on vocational opportunities for unskilled high school graduates. Occupational descriptions for the various jobs created by computer technology are presented, and a bibliography is appended. (BC)

OCCUPATIONAL ANALYSIS OF COMPUTERS IN MEDICAL SCIENCES

U.S. DEPARTMENT OF LABOR
MANPOWER ADMINISTRATION

June 1969

PREFACE

This brochure has been developed to meet the growing need for information concerning computer applications in the medical sciences.

Electronic computers have not only changed the face of the medical health sciences, they are changing the whole structure of jobs. The same basic work—that of improving human health and preventing disease—is being accomplished through new skills, elimination of mental and clerical drudgery, the disappearance of mountains of paperwork, development of new research techniques, changes in medical education, and above all, instant and accurate communication.

Medical thinking has had to become more precise to meet the rigorous demands of the computer. Instead of restricting or standardizing thought, however, this demand for precision has prompted highly creative reappraisals of many medical procedures.

The abilities of the computer are so great, and have had such impact in the medical field, that much of the research thinking, administrative planning, and other medical activities now are governed largely by what the machine can do. New administrative methods are possible; whole new research possibilities are developing; medical education is different, both in content and in teaching methods; and the practice of clinical medicine shows dramatic changes in the management of information.

One of the eventual goals in all of these areas is the establishment of reliable medical predictions based on data other than statistical normals. Applying some of the new mathematical concepts to the computer, it will be possible to establish accurate predictions based on *all* variables of diseases and *all* variables of patients. This will eliminate the problems of

needing a "normal" standard, and focus attention on specific facts in specific situations.

An outgrowth of the successful use of computers to "screen" laboratory test results for abnormalities is the imminent use of "specialist information." Computerizing a specialist's summary of the various critical aspects of his field will enable all physicians to benefit from the information. This also will include summaries of the major advances in the specialty field, since the specialist usually has this information at his fingertips.

With these changes touching nearly every area of medical science, jobs on all levels of complexity are also changing. A necessity for medical experience is the first requisite of these jobs, followed by the knowledge of computer procedures.

There is a great demand in all medical science fields for clerical personnel who are computer-oriented. Most significant among these is the rapidly increasing demand for MEDICAL CODING CLERKS. Women are especially welcome in these jobs because of their known patience with the endless coding details that must be completely accurate.

At this time, there are numerous opportunities in computer-related medical activities for the high school graduate who is willing to enter the medical sciences by the back door. This involves accepting an entry-level job in any department where patient care is provided, mainly to gain medical experience. (Housekeeping or janitorial work are examples.) If this same high school graduate will also take one or two night school courses in computer procedure, he should have little difficulty in moving from the entry job to the much higher level of computer-related activities.

Up to now the developments in computer technology, as applied to the medical sciences, have been occurring at separate points, with little opportunity for the participants to communicate or to exchange information. It is hoped that this publication will help to fill the gap and provide information on these new and developing methods to counselors, students, and others, particularly those who work in the public employment offices or whose activities involve a working relationship with these offices.

The occupational descriptions contained in this volume have been compiled from a number of different sources and therefore describe the individual occupations in a composite, though generalized, form. Consequently, no description can be expected to coincide exactly with any specific occupation in a particular establishment or in a particular locality. To be of greatest use, the descriptions should be supplemented by local information concerning specific occupations in the community.

The U.S. Training and Employment Service has no responsibility for the settling of jurisdictional matters or the setting of wages and hours. In the preparation of occupational descriptions, no facts concerning such matters were collected. It should be clearly understood, therefore, that occupational descriptions published by the U.S. Training and Employment Service cannot be considered standards for the determination of wages, hours, or jurisdictional questions.

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The findings of this study relate only to the institutions and organizations in California from which information was obtained and do not necessarily reflect experience elsewhere. However, we believe that those conditions which are shown do represent a general trend and are directly applicable also to other similar situations. Where the experiences in California are not directly applicable, the information about them may be adapted to reflect with greater accuracy conditions prevalent elsewhere.

CONTENTS

CONTENTS

INTRODUCTION

HISTORY

On display in a British museum is the world's first calculating and printing machine, called the Difference Engine—forerunner of the modern computer. Designed to perform mathematical computations and print out the results, the Difference Engine was demonstrated successfully before 1820. Production of complete, additional models was begun in 1823, but work was so plagued by manufacturing difficulties that production efforts were finally abandoned in 1833.

A century later, the increasing size and complexities of business and government once again directed attention to the inviting potentials of the old Difference Engine. A machine that could perform complex calculations, compare numbers, store some of the figures for future use, and print out specified results, was sorely needed. By the mid-1930's, many scientists and technicians were attempting to develop such a machine, but the first dramatic response to the demand came a few years later with the appearance of the electromechanical computer, fashioned by Aiken of Harvard University in conjunction with IBM. Modifications of this machine naturally followed, and in 1946 the first electronic model was introduced offering vastly improved speed and stability of operation.

Improvements continued. Transistors replaced bulky vacuum tubes and increasingly sophisticated hardware permitted such advances as internally stored machine instructions, built-in error controls, and disc and drum memory units that preserve entire operations for immediate access. Business, government, and industry rapidly assimilated these and later models into their work methods and the resulting revolution of procedures and jobs is well known.

However, the impact of computers in the field of the medical health sciences has been different. By the late 1950's, many medical investigators and hospital administrators, struck by the great potential value of computers, had begun working with computer specialists. Engineering firms were joining forces with medical institutions and schools in efforts to resolve the many different medical data processing problems. But it was found that computer procedures and programing, which were highly successful in business and even in the physical sciences, were not producing the expected results. The basic differences in the data necessary for effective work in the medical health sciences were much greater than anyone suspected and for several years the results baffled everyone.

DIFFICULTIES OF COMPUTER CONVERSION

It is important to grasp the distinction between medical and business problems because this difference touches every aspect of present-day use of computers in all the medical health sciences. Moreover, inability to recognize and learn this basic but unspoken difference prevents workers from successful transfers into medical science jobs.

In business, government, and the physical sciences, the basic information is factual. Whether it is last year's sales volume or a calculation of airplane stress factors, the component information is reasonably exact and everyone concerned knows what it is. Translating these facts into mathematical quantities and then incorporating a variable and studying the result is not too difficult.

In the medical field, however, there are not many quantifiable facts. Only the overall picture (health, sickness, behavior) is known, and the problem is to determine what the components (causes) are, and how they function. Taken by itself, human illness is actually a narrow-range response to an infinite number of possible damages and degrees of damage, both mental and physical. But no two persons present exactly the same symptoms from the same cause; and even communities respond differently to epidemics of the same virus.

The goal, or end result, of all activity in the medical health sciences is improved health and patient care—not units of production or sales volume. Good health can be recognized, but it cannot be measured, any more than a good flavor can be weighed. As a result, medical people are accustomed to dealing with many sets of changing, unpredictable, and often unknown information about illness and injury, and they are thoroughly oriented to goals that are qualitative, not quantitative. Successful navigation through these endless uncertainties requires firm reliance on human qualitative judgment, combined—whenever possible—with quantitative evidence.

This necessary blend of qualitative and quantitative factors is unique, often inapparent, and so taken for granted by people in the medical health sciences that no one was especially aware of it until the standard computer procedures failed completely to handle medical science information. It became clear that a great deal of medical meaning relies on mutually understood implications. The workers speak in terms of quantifiable facts, but they often refer, implicitly, to judgments and relationships that everyone—in the medical field—understands. This unspoken understanding stems from a common background of medical science experience and knowledge, and it is on the total understanding—not on the facts alone—that action is taken. By making one statement, medical personnel often mean something else entirely.

Unaware of this hidden pitfall, computer specialists began analyzing and assembling masses of data at face value and entering them in the computer. In response, the computer manipulated the data as ordered and printed out fact sheets showing that 63 patients had performed their own surgery; the average height of outpatients was 2 inches; and several patients were discharged from the hospital with 21.7 diseases each.

Careful investigation of these bizarre findings finally pinpointed the real and continuing cause: Medical data itself rarely contains the meanings of, or shows the relationships to, the actual facts at hand. Medical

people automatically provide this mental bridge; others find it impossible.

Following these early difficulties of computer conversion, the basic task became that of sorting the implicit and the qualitative factors in medical science from the quantitative. To achieve this, the work is performed by individuals thoroughly familiar with the medical sciences, both physicians and nonphysician scientists. Computer specialists are needed and utilized extensively as consultants. Today these physicians and scientists are developing the computer ideas and the logic by which programs are controlled.

These experts come from every specialty, because there is no area in the entire range of the medical health sciences in which computers are not being used to advantage. Aerospace medicine, psychiatry, public health, dietetics, intensive care units, blood banks, medical training, patient billing—all of them are using computers not only to remove paperwork drudgery and provide instant communication but also to develop new medical methods and strategies heretofore impossible.

SCOPE AND COMMON ELEMENTS OF COMPUTER USE

Some 40 medical institutions in the United States now have their own computers; several hundred others contract for specified computer work or use the computer time-sharing system wherein users may have simultaneous online access to the machine during certain hours of the day. In the time-sharing system, however, it is possible that when the competition for real time operation becomes severe, a project may have to wait for several days to get "on line."

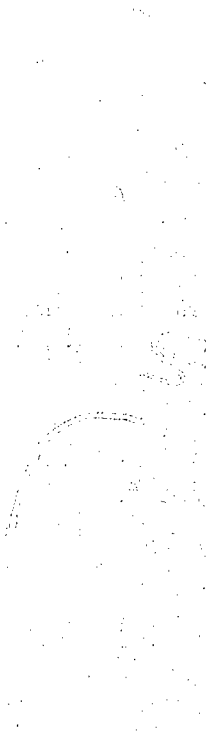
Although continuing assimilation of computer systems into the medical health sciences is progressing rapidly, the kinds of work still vary widely with the specific interests and needs of each facility. Therefore, at this time, it is rare to find two establishments concentrating on the same medical area or meeting personnel needs in exactly the same way.

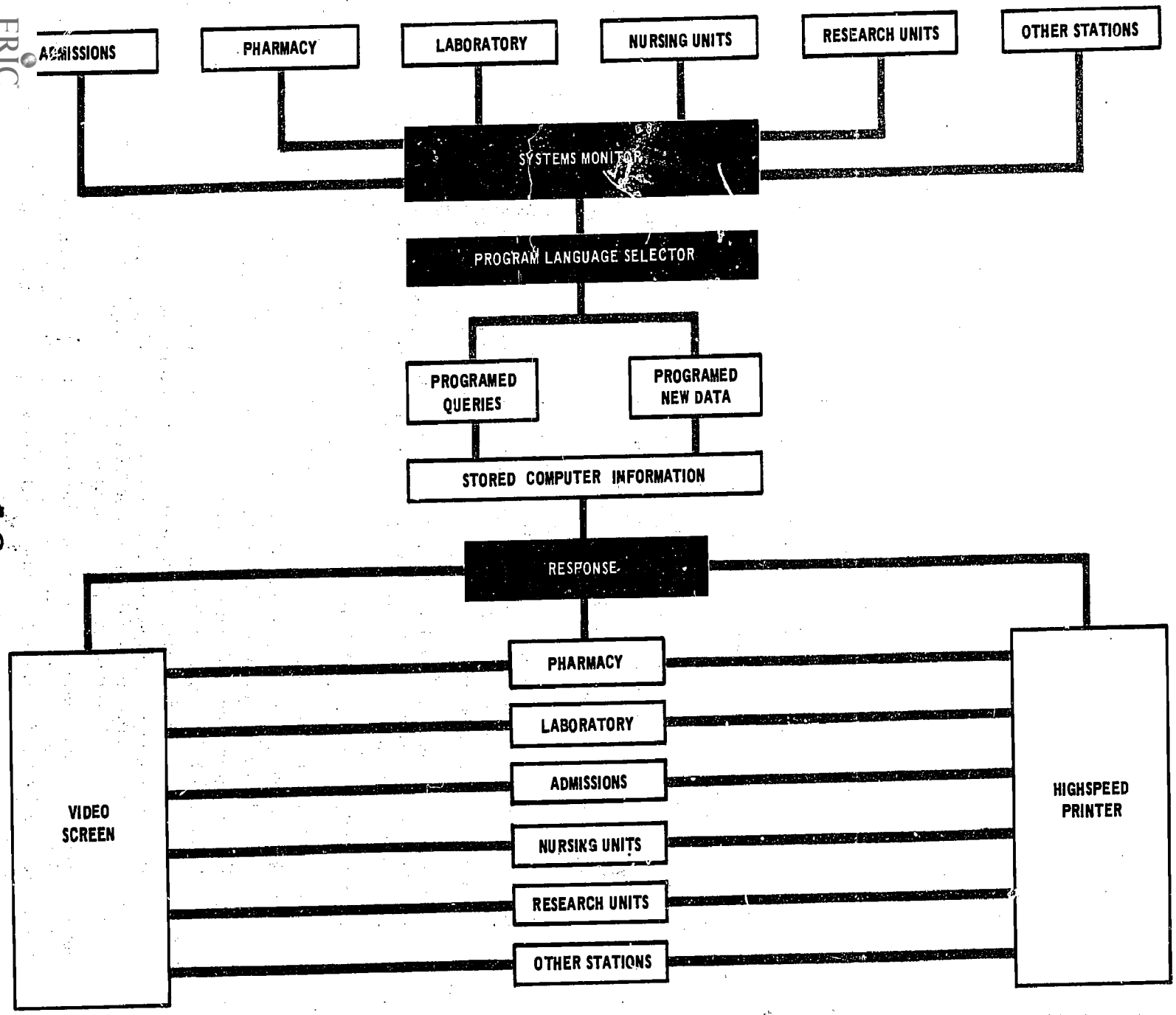
Nevertheless, in any application of computers to medical problems, several fundamental steps are necessary. The following seven are basic to all medical applications:

1). Planning the computer program. This may or may not include extensive systems analyses.
2). Programing and coding.
3). Transferring codes to punchcards or tape.
4). Assembling the program and printing it out to detect errors.
5). Preparing the medical data for computer use.
6). Conducting trial runs of the data and correcting errors.
7). Storing final data on tape, discs, or drums for future use.

All of these steps, except the actual keypunching or typing and the final transfer of data to storage, require personnel who have a medical background as well as a thorough grasp of computer operations.

The use of computer methodology in medical projects has been extensive and varied. But generally, these uses fall into four main categories: *Clinical, Medical Records* (including statistical reports), *Education,* and




ADMISSIONS
PHARMACY
LABORATORY
NURSING UNITS
RESEARCH UNITS
OTHER STATIONS
SYSTEMS MONITOR
PROGRAM LANGUAGE SELECTOR
PROGRAMED QUERIES
PROGRAMED NEW DATA
STORED COMPUTER INFORMATION
RESPONSE
VIDEO SCREEN
PHARMACY
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ADMISSIONS
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Research. This brochure does not include all the specific medical uses of computers, but those that are most representative are included in the following paragraphs.

HOSPITAL AND CLINIC COMMUNICATION PATTERNS

The moment a patient is admitted to any large hospital, pertinent information is sent to 30 different areas, such as the telephone switchboard, the dietetics department, nursing station, surgery, medical records—and finally, the accounting office where information is recorded concerning the patient's Medicare, insurance plans, and any public agency that might be involved. More records and reports develop daily regarding medical and laboratory services provided to patients, supplies and equipment ordered for the hospital, salaries, and statistical reports required by State laws and various accrediting organizations, such as the American Hospital Association.

A comparable network of communication is triggered each time an outpatient visits a clinic. But here, communication is even more complex since a patient may be seen in two or more clinics on the same day, and at each one may receive orders for various laboratory studies, plus appointments for future visits. In addition, each clinic's clerical personnel must arrange the appointment schedules of every staff doctor according to his availability.

With increasing numbers of patients being treated in hospitals and clinics, health service personnel have been faced with mounting recordkeeping problems. One analysis showed that 6 hours of clerical work are required for every day each patient is hospitalized. All authorities agree that manual processing of reports and other necessary information is no longer prompt or efficient.

In many institutions the mounting volume of paperwork is being reduced by converting the entire information network to computer systems. Most of them began with conversion of the accounting and billing systems and then expanded into other areas of medical activity. Many of the smaller hospitals confine their computer procedures to purely business aspects until regional computer services are more fully operational. The smallest hospitals are expected to abandon the old manual systems within a few years.

Looking ahead to that time, one hospital executive states, "Within 10 years, the only medical documents on file in a hospital will be birth certificates, legal consent papers, and death certificates."

A diagram of a typical computerized system is shown on page 4.

CLINICAL MEDICINE

This broad label covers all medical evaluations of patients' symptoms, laboratory and other types of tests, and the treatment of diseases and injuries. It is, in effect, a large group of specialties which evolved due to the rapid advances of medical knowledge. Among specialties such as dermatology, surgery, psychiatry, and pediatrics, the specific kinds of patient information needed for successful medical care vary widely. Moreover, the evaluations of basic information (the patient's age, weight, occupation, etc.) differ sharply from one field to another.

No one person could possibly keep abreast of all these fields and no one computer system could cope with the results. Each specialty requires its own method of accurate systems analyses and conversion of data to computer processable forms. This in turn requires experience in the medical specialty. Therefore, the most successful computer methods to date utilize professional medical people—first, to learn computer systems, and then to adapt the systems to their own needs. This accounts for considerable differences in computer methods, equipment, and results. But these differences do not seriously affect the emerging jobs.

In all areas of clinical medicine, the computer's unique abilities to serve as a giant file with instantly accessible information, to compare new information against a mass of previously filed data, and to print out the results rapidly have made it an invaluable tool. Some of the most typical uses follow, beginning with the hospital and the clinic.

DIAGNOSTIC SCREENING OF PATIENTS - THE AUTOMATED PHYSICAL EXAMINATION

Entering an outpatient physical examination clinic, a patient checks in at the reception desk, exchanges his clothes for a loose-fitting white gown, and receives a packet of prepunched cards. Two hours later, he is dressed and ready to leave the clinic, having had at least 18 different tests, ranging from blood analyses to vision measurements. Most of the test results are already in the computer "file," along with the results of an extensive questionnaire the patient filled out while he was waiting at various test stations.

Should any of these test results indicate serious unsuspected illness, the computer will print out the findings, together with possible diagnoses,

and the patient will be escorted to the proper section for further examination. Otherwise, he makes an appointment to see his regular doctor in a week. At that time, the few tests, such as X-ray, that require medical interpretation before the report can be made, will also be recorded in the computer.

The tests themselves are diagnostic screening tests designed to detect any of the common ailments that often begin without noticeable symptoms—blood pressure, glaucoma, pulmonary emphysema, or a minor coronary. For the patients, it is cheap, comfortable, and quick; for the physicians, this wealth of test information is an excellent reference point for any future illness the patient might develop and the results may spotlight some unsuspected threat to a patient's health.

One California outpatient clinic sees 4,000 patients each week, and by substituting computer processes for much of the usual paperwork, does so without taxing the personnel or delaying the patients.

A physician points to a computer video screen, using an electric light pen to give orders concerning his patient. The keyboard is used to enter data into the computer.

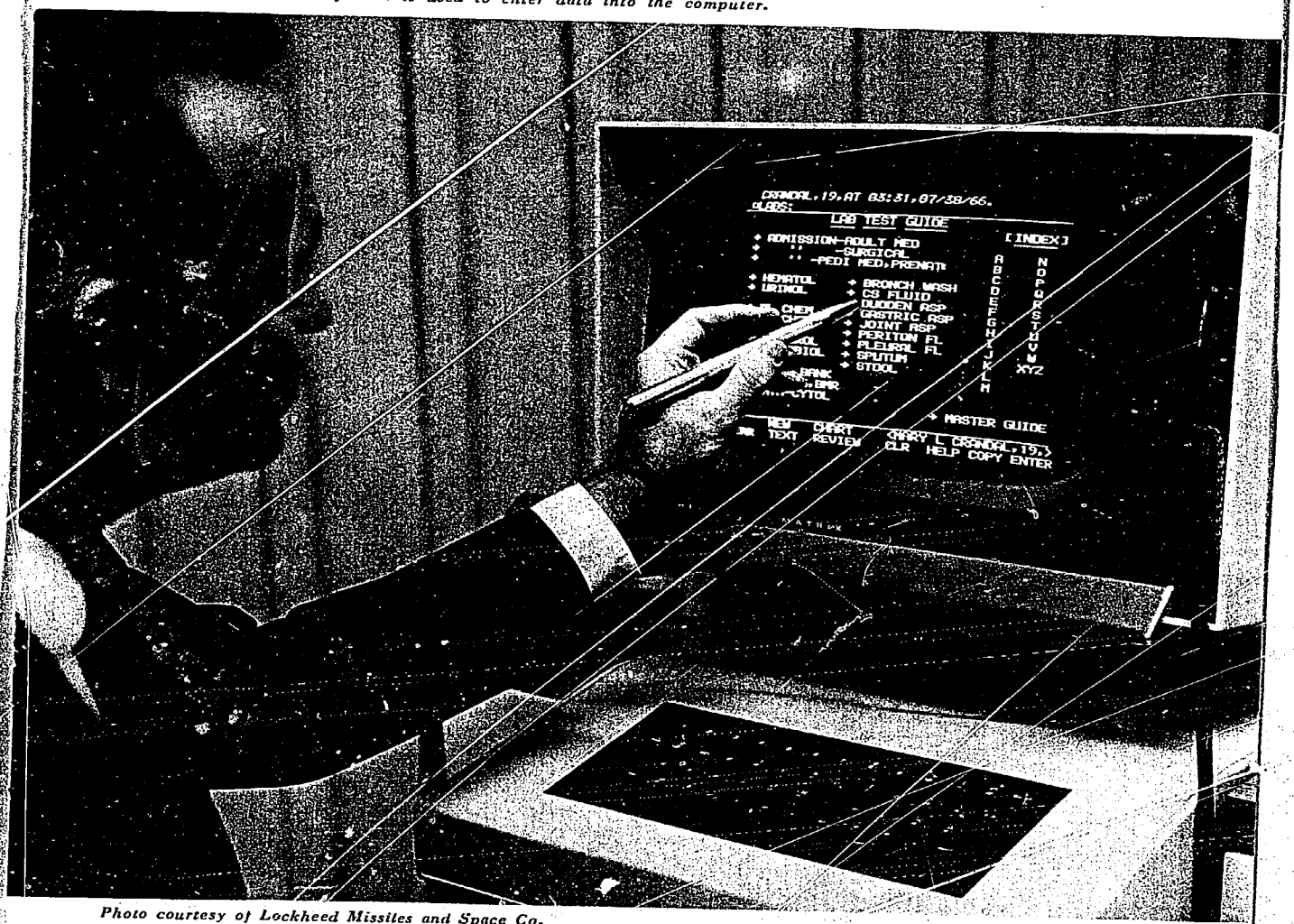
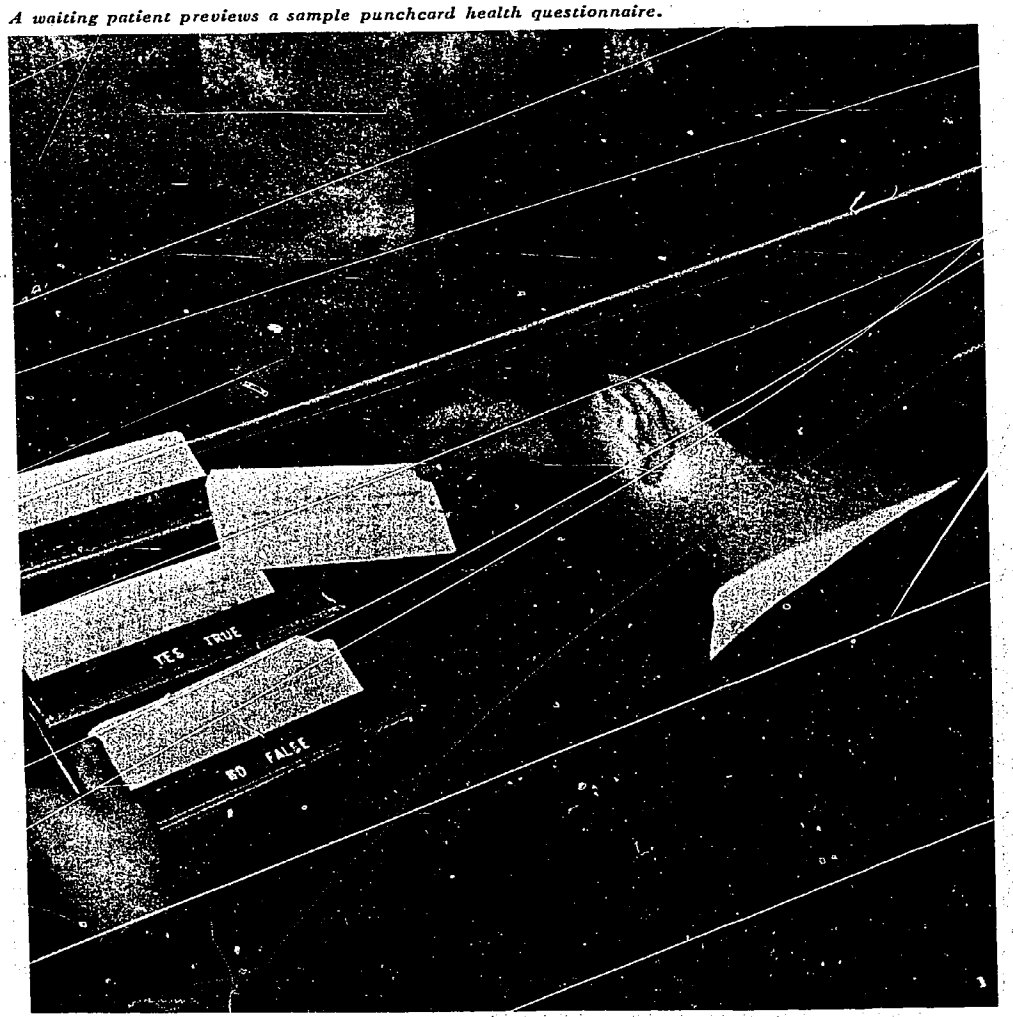


Photo courtesy of Lockheed Missiles and Space Co.

The patients present to each testing station a labeled punchcard which is filled out by the operator and returned to the patient at once. After his last test, the patient hands the pack of cards, together with questionnaire forms and punchcard, to the data processing personnel stationed in the clinic. The material is scanned for completeness and accuracy, run through a reproducing punch, and sent through pneumatic tubes to the computer room for online entry of all data. Results are printed out in a matter of minutes.

These procedures have not materially changed the duties of medical personnel, but the medical environment has had a marked effect on the duties of the data processing workers. Functioning under pressure, and at high speed, these individuals must understand and anticipate medical and clinic procedures in order to scan and process the test data without serious error. Medical orientation is totally different from that of workers concerned with the same kind of machines in business or industry. This knowledge is acquired only through work experience in a medical setting.

A waiting patient previews a sample punchcard health questionnaire.



Consequently, workers who are hired as skilled operators of the various peripheral equipment machines like the reproducing punch or key-punch are closely supervised for at least 1 month and are not allowed to make independent decisions for another 5 months.

Also affected by the unique demands of the medical field are the workers who observe procedures in order to improve the punchcard formats and other forms used in computerized procedures. (See SYSTEMS AND PROCEDURES ANALYST.)

The diagram on page 10 indicates the routing of patients through the automated physical examination clinic. An operator is stationed at each examination booth and nurses are placed at strategic points along the way to assist patients. Not shown is a small data processing room located in the clinic proper.

Applying the computer's ability to receive and evaluate enormous quantities of data, several kinds of clinics, including those in the field of psychiatry or mental health, use written screening devices to locate and record signs of trouble.

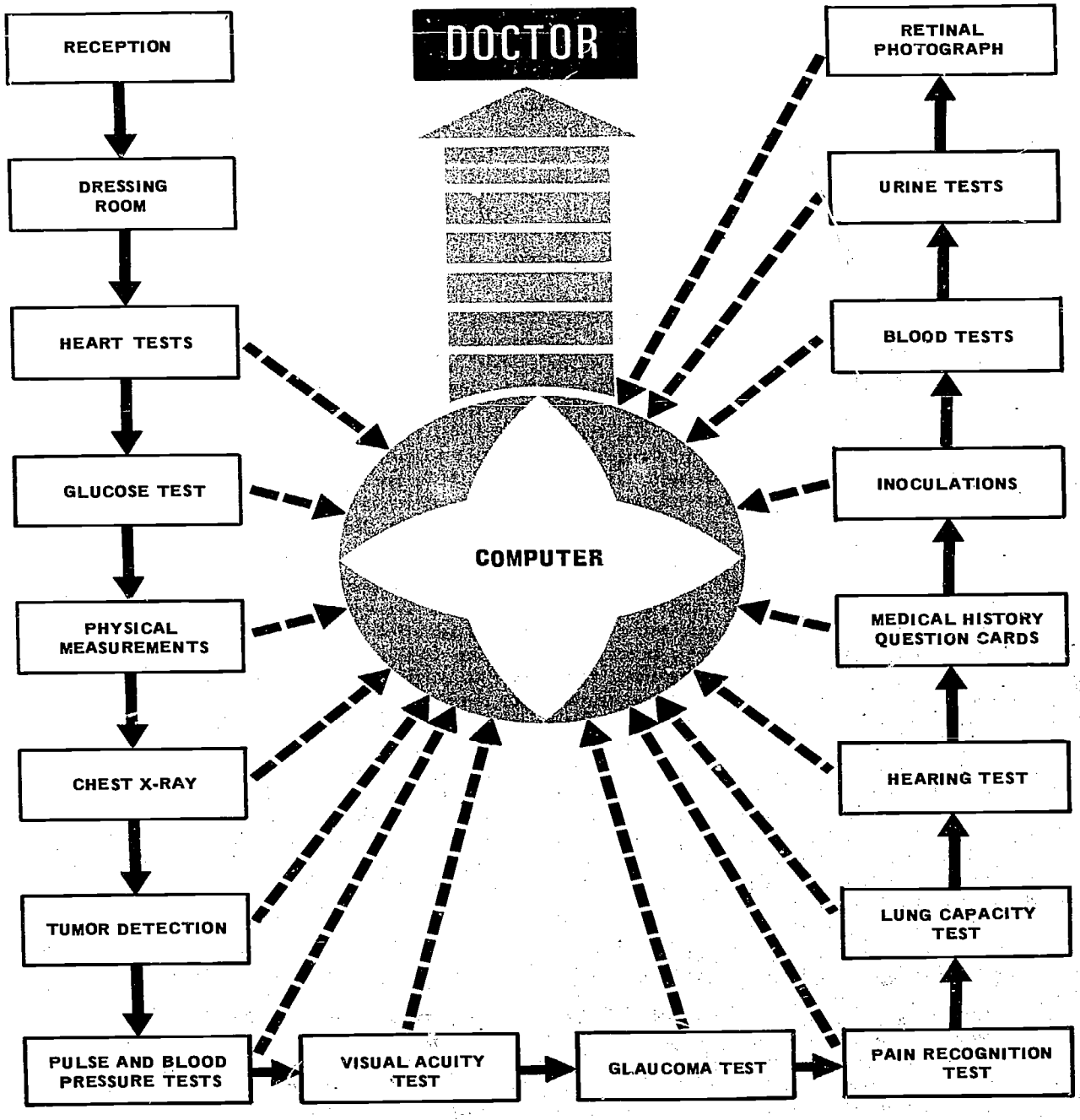
In these instances the patient answers numerous questions about his health, personal history, or attitudes, using specially prepared forms or prepunched cards. Attitudes might be measured by the Minnesota Multiphasic Personality Inventory in which the patient is given a choice of answers to each question. He might be given a list of health history questions adapted from the Cornell Medical Index and to which he answers "yes" or "no." The answers are rapidly converted to computer codes and compared with prescribed standards already filed in the computer. The result is printed out as a tentative profile of the patient. This gives the physician or psychiatrist an excellent starting point and eliminates much of the time-consuming history-taking tasks.

A highly successful variation of this method, developed both for normal, preliminary history-taking and also for use with certain types of psychiatric patients, involves a patient's direct communication with the computer. The individual is seated before a simple keyboard and shown how to use it to "talk" to the computer. The medical worker then leaves the room and the patient taps out his comments or replies and reads the computer's response on the printer or video screen in front of him. With many perfectly normal patients, as well as with selected psychiatric patients, this direct communication often has proved far more informative than initial face-to-face discussion of symptoms or problems. This method also has spotlighted many of the numerous semantic problems that beset the whole field of psychiatry and, to a lesser degree, medicine, since most of the programing necessarily revolves around the various meanings of words. This unexpected information has in turn assisted the professions in their own research.

DIAGNOSTIC PROBLEMS

When a patient shows symptoms that defy a ready diagnosis, the physician often turns to other case histories. But cases are filed by diagnoses, not by symptoms. Therefore, to find cases that might show symptoms similar to those of his patient, the doctor must leaf through dozens of cases—frequently with no success. Few doctors have time for that.

ROUTE OF PATIENT THROUGH AUTOMATED PHYSICAL EXAMINATION



By using the computer, however, all cases in the file can be scanned in a matter of seconds. This may be 1,000 or 5,000 cases. The physician merely writes out the key words of the symptoms that interest him, and the computer instantly prints out the summaries and final diagnoses on all the cases in which the same symptoms are reported. Then, the physician can obtain enough additional information from the computerized case history data (results of surgery or special tests) to enable him to cope far more quickly and effectively with diagnosis of his patient's symptoms.

In no instance, of course, can a computer actually diagnose any illness. At its peak performance, the computer simply compares a patient's symptoms with established norms and reports that the data from the patient are or are not similar to those found in patients with specified diseases. The computer is reporting what has been found in some other patients. This information must then be interpreted in the light of many other factors. Only a physician is qualified to make this interpretation.

Personnel engaged in processing the medical data required for computer processing of symptoms and diagnoses must have a high order of programing ability. In addition, they must have a thorough knowledge of the various approaches to medical problems and the terminologies that characterize each specialty. In some instances, the computer program must even anticipate the patient's or the physician's use of words, which means planning alternative computer actions for all the words and phrases that have ambiguous meanings.

Capitalizing on the fact that each medical specialty commonly uses its own well-defined terminologies, medical personnel have been able to devise specialized patient-history forms on which the physician fills in the appropriate word. These words are coded, as are the statements in which they belong. Handwritten narratives are then required only for unusual findings.

With this material, the computer can record, compare, and print out the pertinent data of 100 cases in a few minutes, as opposed to the 15 physician-hours required to review the same cases and summarize the same data.

Using a similar approach, the specialists in other clinics have developed unique dictionaries of diagnostic terms for their respective medical specialties. Usually, several hundred synonyms can be reduced to less than a hundred diagnostic phrases that are then converted to computer use. Since the unusual handwritten narrative material also uses the terminology of the specialty, it can be converted word for word to computer language and subsequently printed out exactly as the narrative was written.

INTENSIVE CARE

Critically ill patients cannot afford the delay required for the laboratory tests that aid the physicians in determining the next step in treatment. Time is limited. A heart attack, infection, or automobile accident has been too great for the individual to absorb. Physiologically, his system is completely unstable and death may be a couple of hours away.

To establish the vital facts about the patient's apparent heart attack, or probable kidney failure, or possible internal bleeding, the physicians need

tests. But at this point in a patient's life, with not a moment to spare, physicians have simply had to guess. With the advent of the computer, this serious handicap in treating the critically ill patient has been largely removed. Through instrumentation, automated test equipment is attached directly to the patient and electronically connected to the computer. Readings of the test results are taken on a nonstop basis, reported directly to the computer, and the results are immediately displayed on a video screen at the patient's bedside. Other information about the patient can be entered into the computer at any time by medical personnel, using a bedside keyboard, and all of the information can be summarized on command and either printed out or shown on the screen.

This method enables the medical team to see at a glance what is going on in the patient's system and to compare the present situation with the one of 10 minutes ago, an hour earlier, or any other past time. In this way, the effect of treatment also can be seen and guided almost as it occurs.

Near the intensive care unit is the computer room which serves as the nerve center for the thousands of electronic signals coming from the continuous operation of the automated equipment attached to the patient. Functioning 24 hours a day, the equipment is manned by technical personnel who are highly skilled in computer troubleshooting and are thoroughly familiar with medical and hospital procedures in general and with the demands of the intensive care unit in particular. The medical familiarity is usually developed on the job since the paramount importance of these workers lies in their ability to operate and troubleshoot computers.

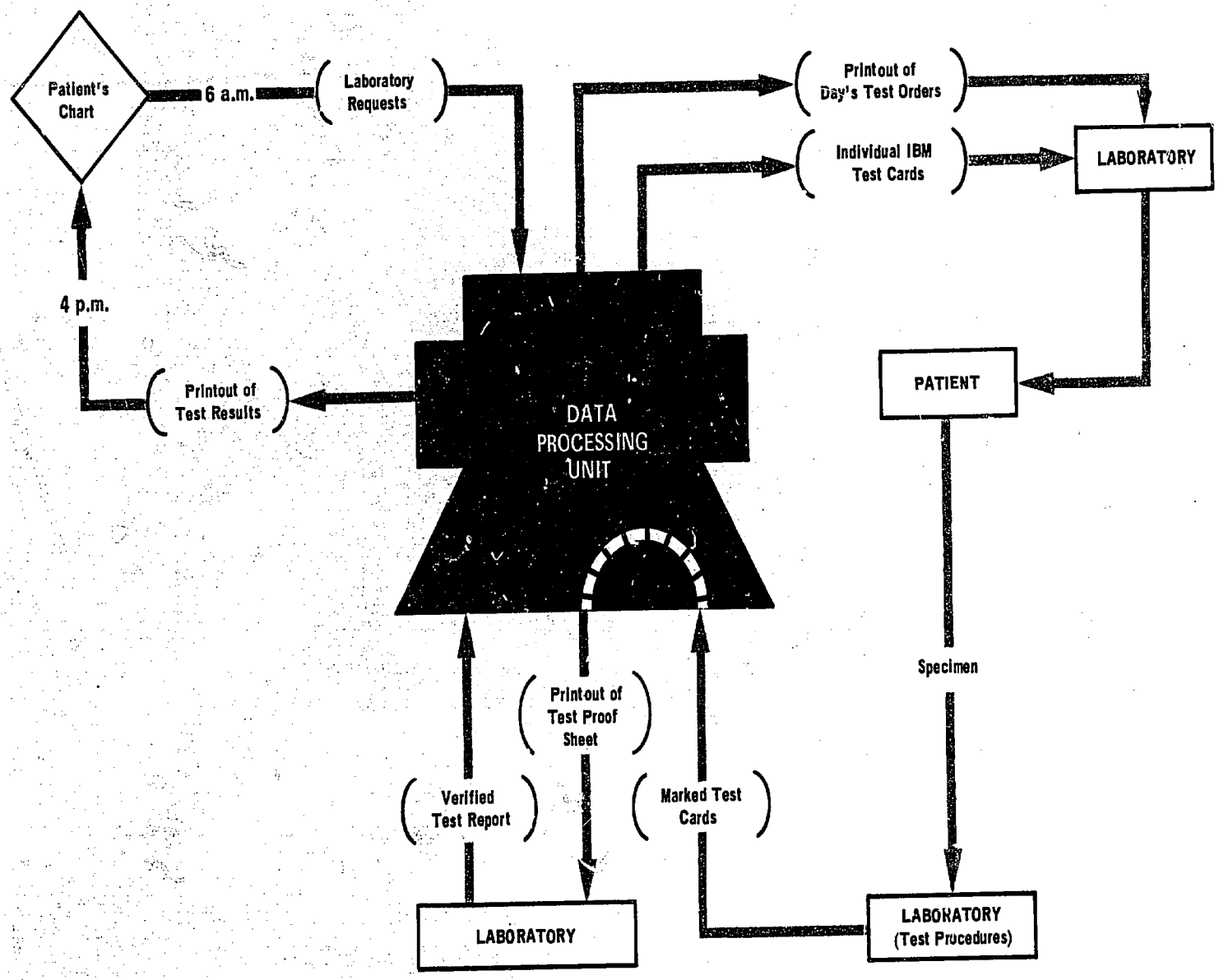
AEROSPACE MEDICINE

A sharp contrast to the critically ill patient in the intensive care unit is the astronaut, circling the earth in a satellite ship. Built into his carefully designed space suit are recorders of the cabin's gravity pressure, air temperature, and humidity, along with devices that record the pilot's heart actions, blood flow, and many other physiologic conditions. These electronically recorded signals are constantly beamed back to the launching site and entered directly into computers for immediate processing. A split second after the signals reach the computer, complete analysis of the pilot's health data is on the video screens and printers for evaluation by the aerospace medical team. This continuous stream of information enables the aerospace physicians to radio instructions to the astronaut at the first sign of potential physical difficulty. As in the hospital computer room, aerospace medical computer personnel must understand and anticipate medical action in order to work effectively with the physicians, both in the planning and checkout stages and during actual flight.

CLINICAL LABORATORIES

Use of the computer in the clinical laboratory reporting procedures has had a dramatic impact on the flow of information into and out of the laboratory and has eliminated a great deal of formerly essential paperwork. Accuracy of reporting is improved. Rapid evaluation of the effectiveness of new techniques is now possible. And computerized information also provides daily reports of such vital medical matters as the incidence

TYPICAL COMPUTER INFORMATION FLOW IN CLINICAL LABORATORIES



of bacterial infections in the hospital, or the patterns of laboratory test results following administration of specified drugs to patients.

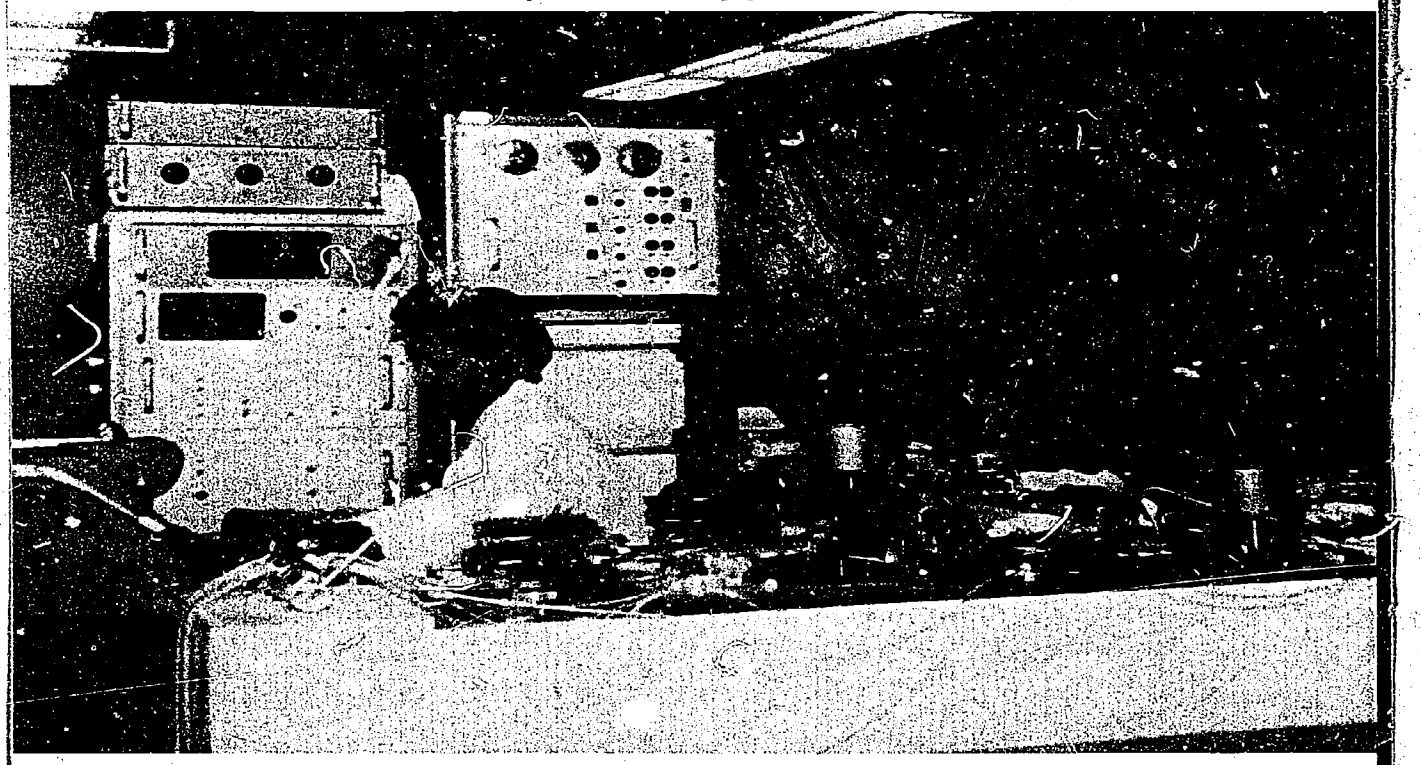
The diagram on page 13 illustrates the new information flow in a typical institution that has converted laboratory data to computers.

Computer reporting processes have necessarily effected major changes in the planning function of the CHIEF MEDICAL TECHNOLOGIST, and the addition of a MEDICAL ANALYST-PROGRAMER to the staff (often a former Medical Technologist) is generally required. Beyond that, the changes in personnel duties are minimal. All of them simplify and expedite the necessary tabulating, verifying, and reporting of tests as well as subsequent analyses of laboratory results that are part of successful laboratory operations. Above all, the test results are now in the patient's medical record on the same day the test is performed and often within an hour of the request from a physician.

There are, of course, marked changes in many tasks of laboratory personnel, but these are due to the use of automated equipment. Chemical studies that formerly required skilled Medical Technologists working a full day are now performed by machines in a fraction of that time. Results are recorded and, through electronic hookups, are entered directly into the computer.

Automated equipment is welcomed by most laboratories as the only means of keeping up with mounting workloads. The trend is clearly in the direction of hiring MEDICAL LABORATORY ASSISTANTS who

A Medical Technician operates automated equipment.



perform routine, repetitive tasks, and proportionately fewer but more highly skilled Medical Technologists who are knowledgeable concerning automated equipment and computer recording methods.

This proportionate reduction of Medical Technologists in each computer-related laboratory is, however, amply offset by the ability of the establishment to handle greater workloads and by the growth of centralized and regular laboratories.

PHARMACY

Each day, a hospital pharmacy of moderate size will compound and dispense a thousand prescriptions and will fill innumerable orders from wards and laboratories for medical materials such as bandages, sterile solutions, and stock reagents. By law, drugs must be accounted for to the last dram or grain. Labels must be absolutely accurate and there is no margin for error. The daily recordkeeping for all these essential functions is necessary, complex, and extensive.

Among doctors there is constant concern about drug orders that are inadvertently duplicated by different physicians or specific drugs ordered through oversight for patients who should not have them. For example, a patient in the emergency ward whose medical record is not immediately available could be given a drug that conflicts with another medication he is already taking. In the computer controlled pharmacy this could not happen.

Inventory control is another area where errors can have serious consequences. No hospital can afford to be overstocked, yet none can risk the danger of a temporarily bare shelf.

Resolving these problems requires systems analyses of the different procedures in surgery, the clinics, medical wards, and other departments where pharmacy products are used. These significant elements are then incorporated into computer systems that contain information about the patient's current medications, allergies, and diagnoses of prior illnesses. Also incorporated into the system are the procedures concerned with the pharmacy's dispensing and inventory functions. Under such a system, the pharmacist then merely types the order or prescription on a console keyboard. This is immediately flashed on the nearby video screen, along with a warning if the patient is already taking the same, or conflicting, medication. Also shown is the drug lot number and other data for inventory control and billing. The pharmacist corrects any errors, and presses a key to verify the order. Computer peripheral equipment promptly prints out the medication label and performs the necessary bookkeeping, inventory, and billing tasks. Upon electronic command, each nursing station also receives summary printouts of all drugs ordered in the past 24 hours at that station. This one printout eliminates three time-consuming clerical tasks at each nursing station.

DIETETICS

The very nature of food and nutrition lends itself to computer management. Proteins, amino acids, calories, the size of food portions served to patients and to hospital coffee shop visitors, and even the purchasing of foodstuffs—all are treated in terms of quantities. These pounds, calo-

ries, micrograms, and other units are readily convertible to computer use. Therefore, the conversion of many food problems to computer mathematics is relatively easy, as are subsequent manipulations of the data.

As always, the Dietitian interviews the patient and carefully prescribes food in accordance with the doctor's specifications. But now she simply writes down either the specialized daily intakes of nutritive elements or allowable total intake. The computer correlates this data with the currently planned menus and available foods. This eliminates hours of mental drudgery for the Dietitians who can well use the time for other matters. A variety of computer printouts used by kitchen and ward personnel eliminates hours of clerical time formerly spent duplicating this information.

The Dietitians, of course, must understand the principles of programing and the limitations of computers in order to recognize and correct program errors and to utilize computer methods to their greatest advantage. However, since this medical area does rely so heavily on quantifiable elements, there is scarcely any problem inherent in the data to be programed. The program generally is worked out among the Dietitians and a computer specialist.

The effect of computerized approaches on hospital kitchen procedures has not altered the duties of kitchen personnel to any appreciable extent. But new personnel in the form of a Keypunch Operator or Telegraphic-Typewriter Operator is usually necessary. It should be noted that in this one medical area—dietetics—personnel knowledge of medical procedures and hospital practices is not a prerequisite for success.

MEDICAL RECORDS

The most important information in any hospital is known informally as the patient's "chart," and consists of the patient's medical history, the medical, surgical, and laboratory findings, and the various diagnoses and treatment records of each visit and each difficulty. In addition, this manila file folder contains all the legal documents required by the hospital for such purposes as recording births, operating on a patient, treating with radioactive substances, dietary data, medication reports, and considerable other material, coming from virtually every department in the hospital.

After the patient is discharged from the hospital, or between visits to clinics, the folder goes to the medical records department where it is studied by medical records personnel to assure completion of all necessary items. Usually, a chart is not yet complete and must be either held aside pending receipt of final studies or routed back to the doctor for the required information.

Key information is then abstracted from the completed chart by doctors for the subsequent classification and coding that is a major task of MEDICAL RECORDS LIBRARIANS. Correct summarizing of all this data is vital to all future consideration of the information in each patient's chart. It involves sifting through a thick sheaf of papers and condensing all the significant information into a few lines of standard nomenclature. Being a tedious, time-consuming task, this is usually left to the junior medical man, the intern, who probably will never have occasion to use the results and therefore may not grasp the importance of what he is doing.

This leads to inaccurate and incomplete summary data—a mistake that creates a chain of subsequent errors in classifications and codings that may never be discovered.

These incorrectly summarized case histories, together with those charts that are being held aside somewhere, create a large margin of error in searching the files for any given type of history, diagnosis, or treatment.

A different, and overwhelming, medical records problem is that of finding convenient filing space for thousands of file folders. While already short of space, hospitals and clinics must find some way to store thousands of new case histories on overloaded shelves. Moreover, since no one knows when any patient might return, all folders must be on the premises and readily available at all times.

A complete conversion to computerized systems solves both the classification and storage problems and adds several new advantages. An excellent picture of this dramatic change is shown by the new procedures at the UCLA Hospitals in Los Angeles.

Here the MEDICAL RECORDS LIBRARIAN reviews patients' charts for accuracy and completeness and selects the data to be entered into the computer. Where words or phrases cannot be directly converted, synonyms are selected from a specified list of words and meanings so that the medical intent is clearly retained. These data, along with the full text of the diagnosis, are then copied in natural prose onto special forms. The forms then go to the keypunch personnel where the data are punched and entered into the computer.

From that moment on, the data are available at the touch of a button. This availability has proved invaluable in the emergency ward, where doctors cannot wait for a chart to be located. For study, diagnostic, or teaching purposes, the information on hundreds of patients can be obtained immediately according to age, symptoms, final diagnoses, or any other combinations of pertinent data the doctor wishes.

Other elements of the medical record, such as dietary or pharmaceutical information, gradually are being added to the computer "file" on each patient. Eventually, all pertinent data about each of the thousands of patients seen at the UCLA Hospitals and clinics will be available on command and shown on video screens or high-speed printers strategically located throughout the buildings. Similar computerized methods are being developed in numerous other hospitals and clinics throughout the country.

Since the MEDICAL RECORDS LIBRARIAN is directly concerned with the final responsibility for all records involving each patient, it is rapidly becoming imperative that all medical record personnel develop a working knowledge of computer operations and computer limitations. For whether the medical establishment has its own computer, or time-shares or contracts computer services, the techniques involving medical records are the same.

Specifically, MEDICAL RECORDS LIBRARIANS need a working knowledge of programing codes and techniques. Supervisory librarians must now develop skills in determining what information is "hard" and can be converted to computer codes immediately, and what information is too "soft" for coding and must be clarified by the doctor before it can be utilized.

Whether or not the initial input and output of information are in natural prose, all information must be coded at some point for use by the computer. This means defining and quantifying all the data in some realistic way. Wherever definite labels, like names for parts of the human anatomy, are concerned the task is not too difficult. But hundreds of other medical words mean different things in different contexts, and physicians must know the whole setting before the meaning is clear. So it is in this area that the selection of summary words for coding becomes critically important. Arbitrary decisions cannot be made.

For example, how can a complex variable like "anxiety" be entered in the computer when the experts themselves do not agree on its meaning? Or how can anyone determine at what precise point a headache becomes significant? How can anyone pin down the various degrees of illness, uncertain diagnoses, or unclear results of treatment? And yet all of this information must be quantified in some manner.

To resolve these difficulties, physicians and the DIRECTOR, MEDICAL DOCUMENTS compile a long list of synonyms to be utilized by the interns and librarians in summarizing and classifying data. Each synonym is coded to one specific meaning, and the workers select the appropriate synonym according to the intent of the medical data at hand.

Noting that this is not always satisfactory, medical personnel are beginning to pay much more attention to precision of thought and language, so that their observations gradually are becoming more systematic. But so long as the English language remains flexible and dynamic, accurate conversion of medical records information to computer codes frequently will challenge the best minds of physicians and librarians.

RESEARCH

Computers are being used extensively in all branches of medical research, ranging from studies of brain activity to growth rates of cancer cells or the biophysics of ulcers. Many research projects rely on the unique advantages of the analog computer; others require the digital computer; and many more use both, either through the use of an analog-to-digital convertor, or by designing a special hybrid machine.

Therefore, workers in medical research must be thoroughly familiar with the demands, limitations, and advantages of the various kinds of computers. In many instances, the specific computer available shapes the whole plan of a project.

Research use of analog techniques consists of mathematical simulation of an environment in which events occur over a period of time, just as they do in the life processes. Mathematical formulas are worked out for the basic data that are known, and another set of equations are designed to represent the variables and the unknowns. The basic formulas are programed into the computer at the start of an experiment, and the variables are added to this data in real time—either as a direct part of an animal experiment, or as an estimated part of a theoretical experiment. Then the results are studied to see, by analogy, what comparable action might have been going on in those aspects of the life situation that cannot be measured directly.

The analog procedures can be adapted easily so that the computer literally becomes part of an experiment. In an experiment concerning brain waves or sleep reflexes or any other biological state, measuring instruments are connected electronically to the computer. Receiving masses of these signals, the computer analyzes and evaluates and gives the investigator a moment-by-moment report of the biological activity. Guided by this running report, the investigator can change the course of the experiment on the spot.

On the other hand, digital computers are ideal for manipulation of static data, such as various hospital workloads, definite descriptions of medical conditions, and laboratory results. Here, too, the data may be rearranged or changed at will, but digital mechanisms do not allow for manipulation of unexpected or varying unknowns. All storage and retrieval of information, of course, must be processed through the digital computer; analog computers cannot handle this essential part of any experiment.

Results from any computer, or combination of types, can readily be made available graphically, either on video screens in the form of line charts or graphs, or through high-speed printers.

Whether analog or digital, however, all research applications of computer techniques follow the same basic pattern and require the skills of most members of the research department, together with selected computer specialists. Unlike other areas of medicine, research procedures require considerable preliminary work before the basic seven steps in computerizing can occur. A simplified diagram of the medical research workflow is on page 22.

BIOMEDICAL ENGINEERING

Struck by the similarity between chemical process plants and the human body, chemists and chemical engineers have become deeply interested in designing substitute organs for the body. Working closely with physicians, these teams have designed successful artificial kidney machines that are well received by hospitals; and wearable artificial kidneys are currently being developed.

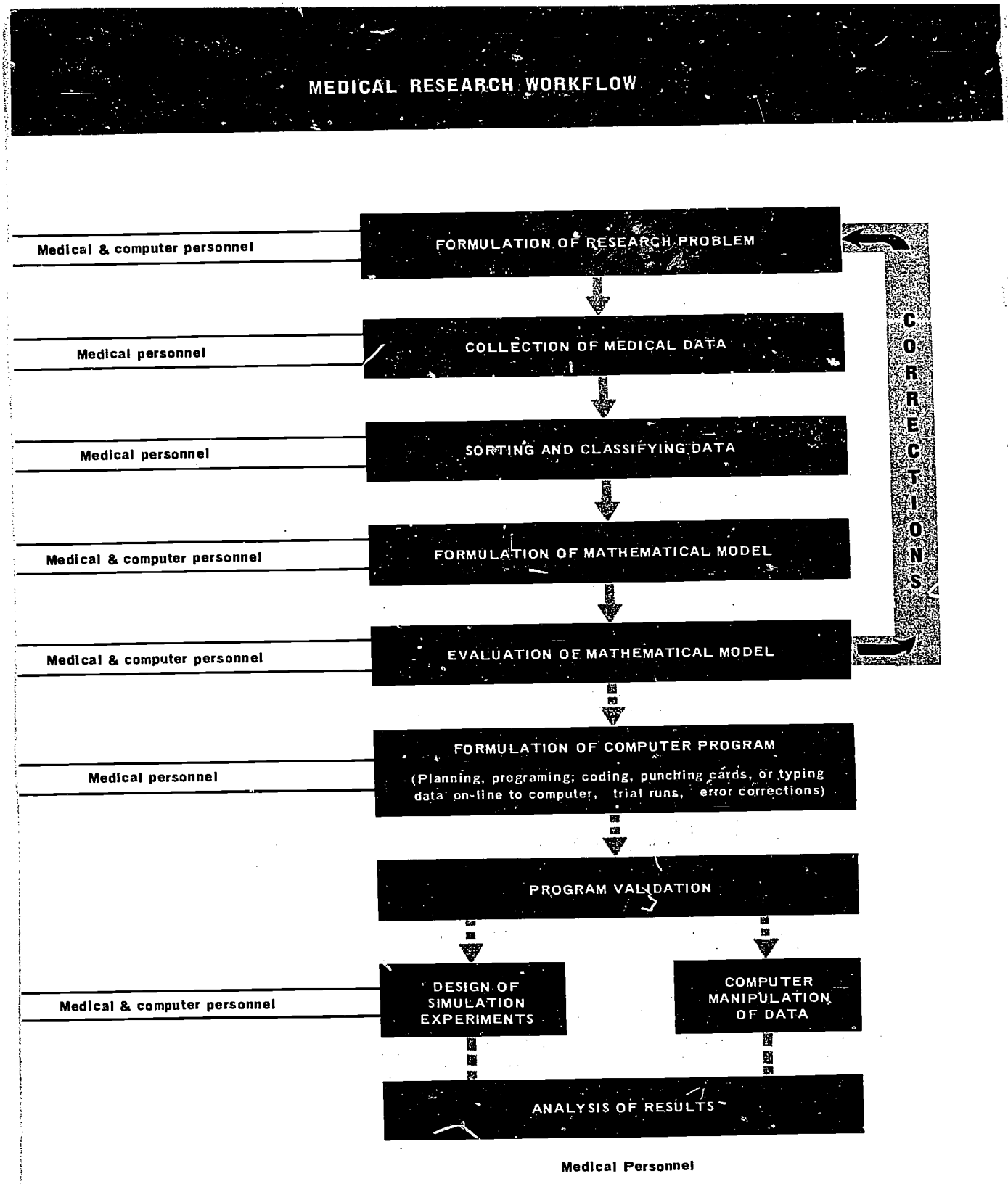
Engineers from other specialties—electronic, mechanical, and even hydraulic—have also been challenged by biomedical problems and are collaborating with physicians in this new field of biomedical engineering to devise other badly needed devices. The tiny electronic gadgets that stimulate and regulate heart action (cardiac pacemakers) are one example; and various artificial heart valves and pumps are no longer uncommon. Meanwhile, work proceeds on the research necessary to develop a workable artificial heart.

Turning to the problem of powering the various devices, these cross-industry teams have become interested in the possibilities of using radio frequencies, nuclear energy, and piezoelectricity (the use of crystals that automatically convert the mechanical energy of bodily motions directly to electrical impulses).

Computers are indispensable to the whole field of biomedical engineering. They are utilized at every step of the research, and again later to analyze the activities of instruments once they are implanted in the human body. The use of simulation techniques on the analog computer is common and somewhat easier than in other medical specialties because of the interest here in weights and viscosities of fluids, pressures of flows, sizes of organs, and other measurable factors.

Effective analysis, both of the reliability of medical data and of computer programs, is greatly enhanced by the precision of language necessary to biomedical engineering. Moreover, workers do not encounter much difficulty in mastering computer techniques—if, indeed, they are not already skilled through their university training.

This new field of biomedical engineering is growing rapidly, but it is still occupied entirely by professionals whose training and experience are mixtures of various disciplines. Subordinate personnel such as Programers, however, should be individuals who were trained previously in some medical area.


MEDICAL RESEARCH WORKFLOW
Medical & computer personnel
FORMULATION OF RESEARCH PROBLEM
Medical personnel
COLLECTION OF MEDICAL DATA
Medical personnel
SORTING AND CLASSIFYING DATA
Medical & computer personnel
FORMULATION OF MATHEMATICAL MODEL
Medical & computer personnel
EVALUATION OF MATHEMATICAL MODEL
CORRECTIONS
Medical personnel
FORMULATION OF COMPUTER PROGRAM
(Planning, programing; coding, punching cards, or typing data on-line to computer, trial runs, error corrections)
PROGRAM VALIDATION
Medical & computer personnel
DESIGN OF SIMULATION EXPERIMENTS
COMPUTER MANIPULATION OF DATA
ANALYSIS OF RESULTS
Medical Personnel

JOURNALS

Published research articles are one of the lifelines in all the medical sciences. Every specialty has its own, worldwide satellite publications, and there are many additional journals of general medical interest.

Currently, some 5,000 different journals are published, and any large medical school subscribes to several hundred of them. But despite the best efforts to keep up with this flood of information, physicians and research personnel cannot know all the developments in their own fields of interest. This simple lack of information creates one of the most serious problems in medical research. Computers are the ideal tool to pull this damaging lack of communication under control. In this instance, computers serve as giant files of data that can produce all specified information in a few minutes.

At the National Library of Medicine in Washington, D.C., the massive files of bibliographies on all medical subjects are converted completely to the Medlars computer systems. This method permits medical library users throughout the country to obtain complete listings, within a few days, of the published articles pertinent to their interests.

To complement this resource, various departments of university medical schools are also establishing their own computer files of medical research abstracts as well as bibliographies. In this way, they have more data than just the title of an article. And they are free to use more flexible computer systems, such as the natural prose method, which enables them to file and retrieve data more readily.

However, both advanced semantic skills and a solid medical science background are required to condense and code medical information—for either filing data into the computer or processing requests to retrieve it. A computer cannot be asked, "What do you have on heart disease?" Instead, there must be a series of highly restrictive, discrete words that convey the precise meanings—first, of the published material, and subsequently of the individuals wishing to search the computer file for specified information.

At the National Library of Medicine, the assignment usually is confined to coding titles of published articles. But at the universities, where data summaries are also filed into the computer, there are more semantic and medical complexities to resolve. Essentially, it must be determined how much of a recognition pattern exists for each key summary word in the mind of the theoretical reader. In view of the increasing dimensions of knowledge and observations in all medical science fields, this selection of words is a complex matter. That is why the work of summarizing and coding information normally is assigned to an INSTRUCTOR, RESEARCH, in each department. He trains clerical personnel to assist him but retains authority to approve all summaries. Typically, he is also the person who enters the data into the computer by utilizing a video screen keyboard.

PUBLIC HEALTH

Both local and national public health agencies are directly concerned with a broad spectrum of threats to a community's health. For example, these agencies must be ready for immediate action at the first sign of

typhoid, tuberculosis, or numerous other contagious diseases; they must enforce the sanitation standards that protect a community's health; and they must remain constantly alert to the potential threat of animal and insect disease carriers.

Computers are being utilized more and more to assist in planning and to telescope the time and paperwork involved in making and keeping a wide variety of reports and records.

Analog computers are being used to great advantage in the simulation of the normal interaction between organisms and their surroundings. This greatly facilitates the planning required to control the spread of any disease under normal conditions (no matter how it is transmitted), and in the event of floods, earthquakes, or other disasters.

Digital computers are proving invaluable in planning and keeping track of local sanitation inspections and activities of the public health hospitals, and in the numerous business aspects of the public health agencies. Plans are also underway to utilize digital computers to screen electrocardiograms for signs of abnormal heart action, so that ultimately there may be widespread, free electrocardiograms for the public—just as there are now free X-rays.

To date, these computer-oriented changes have not added significant new job requirements for most workers in the field of public health. However, the computers slowly are eliminating many routine clerical jobs. This pattern of job elimination is very similar to the one that has already occurred in many businesses and industries.

THE VETERANS ADMINISTRATION

The Veterans Administration is the only large medical facility in the country that provides three distinct kinds of care at the same time, and frequently on the same premises. There is the residential or domiciliary care; treatment of long-term physical or mental illness; and management of acute hospital cases.

All told, the VA has 124 general hospitals; 41 psychiatric hospitals; 16 domiciliaries; and several related medical activities, such as community home nursing services, and medical care provided in conjunction with State or local agencies.

A veteran may find that he requires one or all of these services over a period of time; and it is equally likely that he may receive treatment at one location, and then suddenly appear at another, a thousand miles away, requesting emergency medical help.

In view of the scattered locations of the facilities, the different kinds of care provided, and the various data needed by administrators, counselors, physicians, investigators, and other workers, it is not always easy to get the right patient information at the right time. The medical records problems faced by any large hospital are multiplied many times over at the VA, despite continuing efforts to control them. For these same reasons, efforts to compile the most useful medical statistics for use by Congress or other Federal or medical purposes have also been difficult.

However, digital computers are beginning to prove highly useful in both

processing and summarizing data. Moreover, personnel already engaged in various medical and psychiatric activities at VA establishments have been readily trained to do preliminary analyses of data. To date, these compilations are forwarded to an electronic data processing center for programing and coding. As more and more of its own personnel can be trained, the principal VA facility engaged in this conversion of data will transfer much of the necessary processing to its own staff. And this in turn will create new openings for programing and coding personnel.

EDUCATION

In addition to providing ways of solving many problems, computers are directly responsible for several signal changes in medical education.

Not only new courses, but whole new departments have been established in medical schools across the country. Following in the footsteps of the pioneers who mastered two or more separate disciplines (such as mathematics, neurology, and biochemistry) in order to utilize the important advantages of computers, medical schools and universities now have such departments as biomathematics, bioengineering, and biophysics. Usually under the wing of the medical school, these departments are designed to help fill the growing demands for scientists who can synthesize mathematics, statistics, and the biomedical sciences. In a number of medical schools, the curricula include at least 1 full year of intensive work, utilizing computer methods, to help bridge the gap between mathematics and medicine. Medical students learn not only how to manage computer procedures already in operation but also how to plan and execute their own rudimentary programs.

On the undergraduate level, many universities and colleges have instituted extensive courses in computer problems especially designed for students in chemistry, psychology, the life sciences, and pharmacology, as well as the engineering specialties, such as bioengineering, that now are being utilized in solving medical problems. The impact of computers in all these areas has created a continuing demand for professional workers who can apply some of the enormous computer capabilities in combined efforts with medical scientists. This in turn has had a marked effect on the thinking and planning of educators, as well as the leaders of the professions close to medicine. Most of the occupational doors still open to fledgling scientists who cannot work with computers will be firmly closed within the next 10 years.

In addition, a few junior colleges and universities are beginning to meet the increasing medical demand for workers, such as Programers, who do not need an advanced degree, but who do need a medical orientation. Excellent business programing instruction has been available to some degree for a number of years, but this is not adequate for workers in the field of medicine. As pointed out elsewhere, Programers have not been able to transfer their skills from business or government work into medicine.

This medical orientation cannot be obtained through terminology and

survey courses alone. It must include firsthand experience. There is no other way to provide a good grasp of necessary hospital procedures and the medical reasoning necessary to grapple with a constant mixture of very precise facts and unknown and unpredictable factors.

In high schools, a few scattered districts are beginning to respond to the need for medical clerical workers, such as those engaged in medical coding or operating the computer console, and to the need for workers engaged in instrumentation and repair or construction of medical equipment.

The clerical workers need to know the elementary facts of medical procedures and aim together with the computer's abilities and limitations, in order to avoid the serious errors that otherwise occur. It has been found that this information can be successfully taught in high school, in the same manner that "Business English" has long been taught.

Entry-level craft workers who have learned the practical aspects of chemistry, biology, or other health science in high school are in considerable demand. Given this knowledge, workers in the specialized fields of plastics and resins, plating, coating, and painting unusual materials understand the basic theories in back of their work, and so avoid costly shop disasters.

In both clerical and shop work, employers will train workers who have the appropriate high school background. However, most of these employers have only moderate-sized businesses and have neither the trainers nor the time to teach medical terminology and computer keyboard operations on the one hand, or elementary, applied science on the other.

THE SIMULATORS

Computers have not only changed worker duties (and therefore teaching aims) but they also have permitted a revolutionary advance in medical teaching methods through the use of Simulators. These are electronically powered, computer-controlled models of various portions of the human anatomy. The first one was designed jointly by the University of Southern California, Aerojet General Corp., and the Sierra Engineering Co., and is a life-sized and lifelike model of a human torso and head. In operation since March 1967, the robot-model is designed to substitute for any live patient under anesthesia, and solves the age-old medical problem of training students without endangering patients.

Programed into the computer are all the possible reactions that occur during the three stages of anesthesia, plus all the specific reactions caused by known physical complications, such as asthma, high blood pressure, or cardiac problems.

Located in a mock-surgery, the Simulator is preset, through the computer, to respond to whatever is administered to it in exactly the same way any specific type of patient would respond. Student anesthesiologists apply the actual preliminary and principal anesthetics to the robot, including the insertion of the breathing tube into the "patient's" airway. They watch the "patient's" respiration and muscular reactions, and observe dials of pertinent equipment to determine their own next actions. A student error creates the same serious reaction in the "patient" as it would in actual life. The student must then handle the emer-

gency, but if the "patient" dies, no harm is done.

In addition to these automatic responses to the student's actions, the Simulator is programed in such a way that the instructor can present any of several emergency situations merely by adjusting two or three knobs. Or the instructor may stop the action altogether and obtain an immediate printout of all the physical responses that can be used for on-the-spot review.

Prior to March 1967, the only way a student could master the art of anesthesiology was through direct, supervised practice on patients. Two or three years of such practice was required to give a resident sufficient experience to cope with the range of problems he would meet from then on. This training time has dropped to 2 or 3 months, using the Simulator; and there is no risk to the patients.

Fifteen Simulators are now planned for other parts of the human anatomy, and will be used to train paramedical as well as medical personnel. Available 24 hours a day, and offering endless possibilities of "symptoms" and "reactions," the Simulators will clearly alleviate the major problem of finding 56,000 patients each year whose conditions can be utilized to instruct some 224,000 persons.

A medical resident applying anesthetics to computer-controlled patient Simulator.

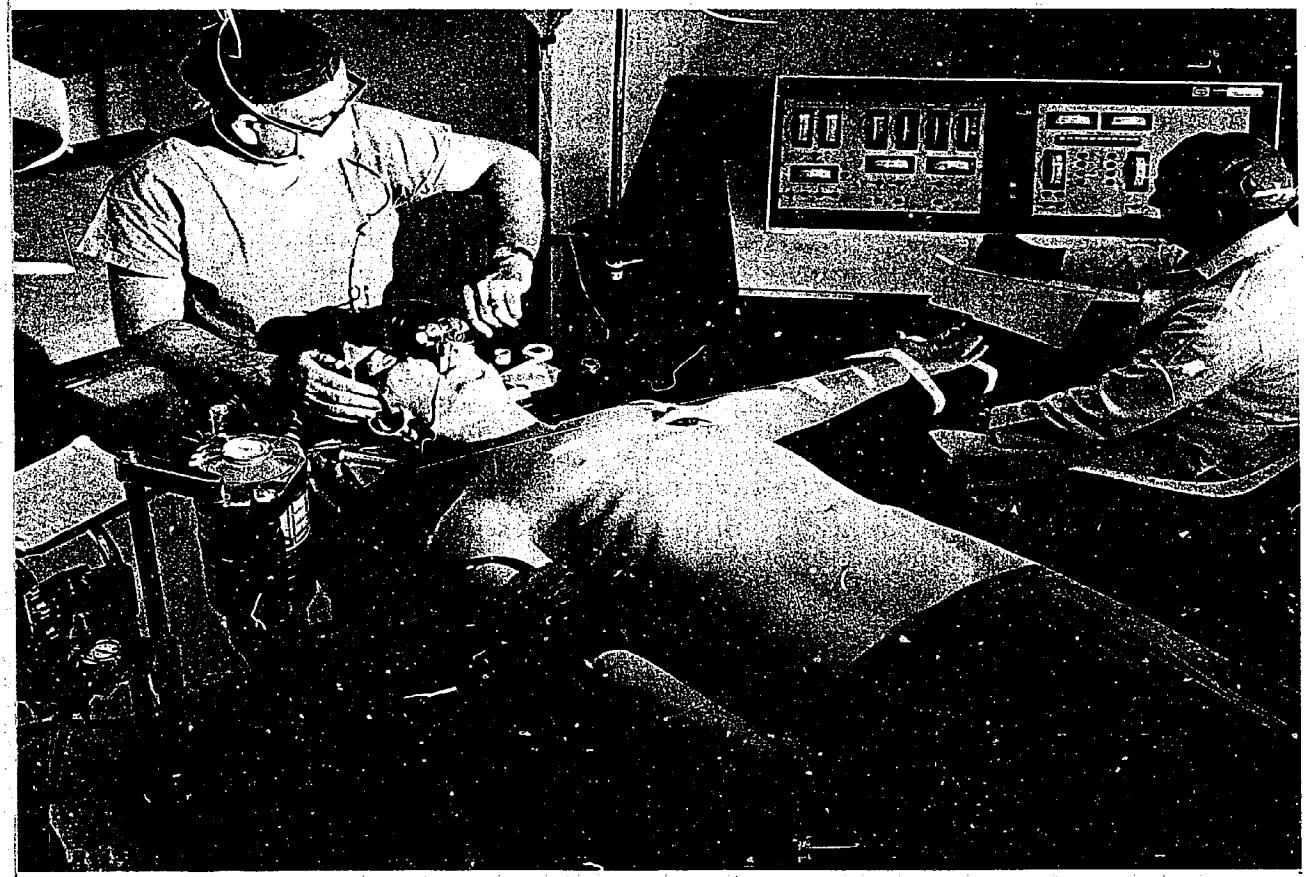


Photo courtesy of Aerojet-General Corp.

EMERGING JOB TRENDS

The demands and advantages of the computer have created new blends of skills and knowledges at all levels of medical jobs. Many have settled into well-defined sets of duties, and these are described at the end of this brochure. But others are still prototypes of emerging occupations, and none of these has sufficiently crystallized—either in duties or in worker specifications—to warrant job descriptions. Nevertheless, they help delineate the major trends of the computer-related jobs that are rapidly developing, and are therefore described in the following paragraphs.

At the top, a new specialty has emerged: The computer scientist. This is a widely educated person with an extensive background in mathematics and computer functions, as well as graduate education in one of the biological fields. Pioneers in the medical-computer field developed this specialty on their own, but today the degree of Ph.D. in computer-sciences is awarded at Stanford University, Carnegie Institute of Technology, Columbia University, and elsewhere. With this degree, the computer scientist may enter business, industry, government, or medicine, and be given any of a wide variety of job titles. Those that enter medicine usually do so through the new field of biomathematics, bioengineering, or the older one of biochemistry. They are concerned with research problems or clinical applications, or both, and usually serve as planning consultants for doctors and paramedical personnel.

An offshoot of the computer scientist is the medical information scientist. Still sparse in number, these pioneers are concerned with information theories on one hand and medical knowledge on the other. The job titles vary, as do the academic backgrounds, but in general these individuals have combined training in the life sciences, social sciences, information science, and medicine. Their purpose is to develop and apply effective methods of translating medical data for computer use, and they follow the information theories to do it.

"Information theory" as presently defined has to do with the recognition of patterns which reduce the equivocation as to the next letter or word, or the next idea, contained in any published material.

On a lower level of job hierarchies, a pattern is also beginning to emerge in some of the clerical jobs closely associated with computer printouts. Here, the workers must have thorough familiarity with the laboratory, medical records, or clinic procedures in order to recognize and rectify illogical computer entries. Some of these workers also type punchcards for direct use by computer equipment. Others, on a higher

salary level, also design new forms and worksheets for recording the computer data, maintain master indices of specialized terminologies, and translate requests for computer information.

At the near-entry level, clerical jobs are beginning to emerge for workers who can learn, quickly, to type dictation or copy medical material, using the magnetic tape typewriters. The machines may or may not be connected to computer peripheral equipment. These workers may also type material directly into the computer, using a special typewriter. Workers who do utilize this typewriter must also master the use of various computer language programs in order to enter or retrieve appropriate data. This normally involves knowing when to switch from a mathematical mode to, say, an informational mode and then to a comparison series in order to properly manipulate the data to be entered or retrieved. To do this successfully requires a clear understanding of program content and programing logic and limitations. Otherwise the workers would become hopelessly confused by the computer responses. In the technical area of computer operations, the personnel are essentially the same as described in "Occupations in Electronic Computing Systems,"[1] except for those separately discussed in this brochure.

MEDICAL SYSTEMS ANALYSTS-PROGRAMERS

In all the medical health sciences, the most sought after man is the one who is involved with medical systems analyses and/or programing. The titles and duties of these jobs vary considerably, depending on the size and goals of the medical department concerned. But essentially, the worker must analyze procedures, evaluate key data according to medical principles, and then plan the necessary programing. Occasionally, the worker constructs the program, utilizing advanced programing skills. More often he collaborates with a trained programer to create a new program for the purpose at hand. Prepackaged systems have not been successful. The demand for these workers well exceeds the supply, and the gap is expected to widen, even though salaries are comparable with Programers and Systems Analysts in business and industry.

However, workers with adequate basic skills acquired through experience in business or industry have not been successful in transferring their abilities to the medical fields. Successful programing rests first on the individual's grasp of the medical orientation, and only secondarily on programing skill.

Therefore, most medical employers now look to their own personnel for these jobs and no longer try to train skilled Programers or analysts in hospital procedures. It has been far more effective to train a nurse, or Laboratory Technician, or MEDICAL RECORDS LIBRARIAN in the skills and techniques of programing and systems analyses.

Of the variety of jobs currently found in the medical programing and systems analyses work, three are representative of the range of duties presently encompassed. These are described in the following pages as MEDICAL SYSTEMS ANALYST, COMPUTER; MEDICAL RECORD PROGRAMER-ANALYST; and MEDICAL ANALYST-PROGRAMER.

[1] "Occupations in Electronic Computing Systems," 1965, Bureau of Employment Security, U.S. Department of Labor.

THE OCCUPATIONAL DESCRIPTIONS: ARRANGEMENT AND CONTENT

The occupations described in this brochure are the basic occupations directly concerned with medical applications of computers. Like the field itself, however, the occupations are expanding and developing, and the hiring requirements are not yet fully standardized. As a result, a certain amount of apparent overlap in duties may be noted, but in these instances the degree of specialized medical knowledges varies sharply enough to warrant separate mention. The information about each job was gathered from several sources and therefore reflects a composite picture. To gain the most from these descriptions, they should be used only as guides to any individual job.

More jobs in the medical field will be associated with computers as the use of computers becomes even more widespread. The existing trends that can be seen clearly at this date are delineated in the preceding section but this is such a fast-changing field that new trends will continually develop for the next few years.

The job descriptions are arranged in alphabetical order. In some cases, other titles or alternate titles by which the same job is known also appear in small type at the head of each description. Below the title is the code number pertinent to the Third Edition of the *Dictionary of Occupational Titles*. Being new jobs, or new combinations of old skills, none of these jobs is yet to be found in the *Dictionary of Occupational Titles*. However, the code number will assist anyone who wishes to relate the occupation to the Dictionary's classification structure.

Occupational Definition—This provides a brief description of the duties involved in a particular occupation. It provides an understanding of the tasks that are performed, and the skills and knowledge that are necessary to the performance of those tasks.

Education, Training, and Experience—This section provides an indication of the amount of education and the level of training and experience usually required by management for employment in the occupation. As previously mentioned, the various occupations and their qualifications are not standardized, and considerable variations exist among employers as to required education, training, and experience. However, an attempt was made to indicate the range of such hiring requirements.

Worker Traits—This section provides some estimate of the worker trait requirements pertinent to the specific occupations. It has long been believed that the ability of an individual to adjust to specific types of work situations is as significant as the education and training qualifications he brings to the occupation. This seems particularly significant when dealing with a group of relatively new occupations. Consequently, judgments have been in terms of a number of components consisting of aptitudes, interests, temperaments, and physical demands and working conditions to which individual workers have to adjust. A listing and definition of each factor for the various components is contained in the Worker Traits Section on page 80 of this publication.

Aptitudes—These are the specific capacities or abilities required of an individual in order to facilitate the learning of some task or duty. This component is made up of 11 specific aptitude factors, and is a modification of the aptitudes contained in the General Aptitude Test Battery developed in the U.S. Training and Employment Service. Those aptitudes were selected which seem to be significant in the

occupation and were identified in terms of specific work situations. The factor of intelligence, however, was not rated because of the difficulty in writing meaningful descriptive statements.

Interests—This component is defined as a preference for a particular type of work experience. It consists of five pairs of bipolar factors, arranged so that a preference for one factor in a pair generally indicates a lack of interest in the other factor in the pair. Those factors were identified which seemed to be significant to the job in question, and were identified in terms of specific worker situations.

Temperaments—The temperament component consists of 12 factors defined in terms of specific work situations that suggest different temperament trait requirements. Each work situation describes a type of activity that demands a different adjustment on the part of the individual worker. Those temperament factors were selected that appeared to be significant to the occupation, and were identified in terms of specific work duties.

Physical Demands and Working Conditions—This refers to (a) the physical activities required of the worker; and (b) the physical surroundings which make specific demands upon a worker's physical capacities. There are six physical demands factors and seven working conditions factors. Those factors were selected that were significant to the occupation in the sense that they met established criteria for successful performance.

DATA HANDLER
213.582

OCCUPATIONAL DEFINITION

Receives prepunched and mark-sensed cards concerning medical histories or laboratory studies from outpatients and technicians in clinic, and processes cards for immediate or batch entry into hospital's computer system:

Scans decks of computer cards submitted by patients and technicians to detect machine errors of double-punching, or incorrect spelling. Keypunches correct new card and inserts it in deck. Places deck in reproducing machine to obtain master punched card. Routes card through pneumatic tube to computer personnel or inserts cards into card reader for entry into computer system. Examines jammed machines for bent or warped cards, or improperly stacked decks, and corrects difficulty. Receives and sorts patient questionnaires by color code and routes them to keypunch personnel for immediate processing.

Receives emergency printouts from online computer recordings of abnormal test results concerning clinic patients, such as high blood pressure or unusual laboratory findings, and contacts the head nurse for prompt attention to patient. Trains subordinate data handlers in operation of peripheral computer equipment located in clinic, and gives them work orders during high-speed operations to prevent delays due to conflict of procedures. Before and after clinic hours, operates peripheral computer equipment in computer room, such as optical scanning and electronic interpreting machines.

EDUCATION, TRAINING, AND EXPERIENCE

The minimum requirement is completion of courses at a business school that gives a certificate in mastery of various automated business machines, including the keypunch. Graduation from high school is highly desirable. Work experience is not necessary, but employers naturally prefer applicants who already have experience with the specific type of equipment they use. Many employers also give a punchcard aptitude test (devised by IBM) to applicants before hire. One month of closely supervised on-the-job training is provided by the employer.

WORKER TRAITS

Aptitudes:

Clerical perception, for rapid scanning of punchcards to detect printing or punching errors.

Motor coordination to pick up and process all data received from a patient, completing the work within 2½ minutes.

Manual dexterity is essential for rapid riffling of decks of punchcards preliminary to stacking them in reproducing punch machine.

Interests:

A preference for organized and routine activities, in order to process specified types of data through keypunch and reproducing punch machines.

Temperaments:

The work of receiving, scanning, typing, and inserting punchcards into the punch machine is repetitive, and must be performed according to specific procedures. In addition, there must be a quick and intelligent response to the problems created by any delays in procedures, because patients, for their own safety, are detained on the premises until all online data is in the computer and the subsequent, immediate printout has been reviewed by the head nurse.

Physical Demands and Working Conditions:

Work is light, requiring standing and walking 4 hours daily while the clinic is open.

Reaches for and handles decks of cards and questionnaires; fingers switches and keys to operate machines.

Near visual acuity to read copy and scan decks of cards for punching errors.

DIRECTOR, MEDICAL DOCUMENTS Principal Medical Records Librarian

100.168

OCCUPATIONAL DEFINITION

Directs activities of hospital and clinic medical records department, and plans and directs conversion of patient information to computer system:

Plans departmental procedures concerning such matters as completing, classifying, and filing patient records; fulfilling the various legal requirements of patients' documents; and protecting the confidential nature of

medical reports. Interprets hospital policies, State laws, and other regulations to subordinates.

Analyzes patients' records to detect patterns of incomplete or missing information, and establishes standards for forms used in laboratories and clinics to assure recording of adequate information, in compliance with State laws and other regulations. Evaluates effectiveness of new forms and modifies them to improve accuracy or economy. Attends meetings of hospital executives to discuss and resolve such problems as delays in receiving physicians' reports, or conflicting priorities of requests for medical documents.

Plans and directs medical records storage in computer system. Evaluates documents in the light of computer requirements of brevity and precise use of language, and determines medical phraseology and terms to be utilized in converting specified data to computer language. Confers with Programers and Systems Analysts to develop systems of numerical and alphabetical coding. Directs subordinates engaged in recording and translating data for use by computer, using knowledge of computer software and hardware, medical terminology, and hospital and legal regulations. Writes and presents papers on application of computer techniques to medical records.

Approves departmental personnel selections, promotions, and discharges. Gives lectures to classes of MEDICAL RECORDS LIBRARIANS.

Director, Medical Documents, examining punchcards and printouts of patients' records.

EDUCATION, TRAINING, AND EXPERIENCE

Graduation from an accredited school for MEDICAL RECORDS LIBRARIANS, and certification as a Registered Record Librarian are essential. Experience should include 3 years as a MEDICAL RECORDS LIBRARIAN in a small hospital to gain a thorough knowledge of hospital activities and problems as a whole. nd 5 more years of progressive responsibility in the medical records department of a large hospital. These 5 years should include at least 1 year as the head of medical records. Additional, necessary training for this job involves at least two advanced courses in computer programing, and one course in the various concepts and difficulties of developing software packages.

WORKER TRAITS

Aptitudes:

Verbal ability to read medical and computer terminologies, and to present oral and written reports.

Clerical perception to read and understand phrases, words, and numbers rapidly and accurately.

Form perception to detect and understand slight differences in computer flow charts and in medical or computer symbols.

Interests:

A preference for business contact with others, to participate in conferences with physicians and hospital administrators concerning problems of medical records and medical phraseology, and with computer specialists to clarify and resolve difficulties of converting data to computer codes.

A liking for technical activities to apply logic in resolving problems of computer applications.

Temperaments:

Ability to perform a variety of duties involving personnel matters, medical records, and computer procedures.

Must be able to plan, direct, and control the accuracy of data and the summarizing, loan system, and computerizing of all medical records.

Must be able to deal with subordinates to coordinate medical records activities and with medical personnel to resolve problems of accuracy or intent of phrasing. Must make judgmental decisions to interpret policies, evaluate records, and determine correct medical phraseology to be used.

Physical Demands and Working Conditions:

Work is sedentary.

Reaching and handling of medical records and computer printouts.

Talking and hearing to instruct subordinates, resolve problems, and confer with medical, administrative and computer personnel.

Near visual acuity required to read computer programs, flow charts, printouts, and a variety of handwritten documents contained in medical records. Color vision to recognize color codes used in medical records forms.

INSTRUCTOR, RESEARCH

090.228

OCCUPATIONAL DEFINITION

Conducts university classes for undergraduate students, and plans and conducts research concerning computer storage of information published in worldwide scientific and medical journals:

Prepares and delivers lectures to students in neurophysiology, psychology, or other scientific fields; and develops, administers, and grades examinations. Directs research of specified undergraduates studying for advanced degrees. Plans and conducts research on methods of evaluating, abstracting, and programing published clinical or research reports for storage on computer tape. Consults dictionaries to verify range of terminology meanings, and confers with specialists in information sciences to determine most effective terms that will describe precise content of articles. Compiles glossary of descriptive terms. Reads programed abstract on video screen of computer, and corrects errors, using online keyboard. Hires and trains clerical personnel engaged in abstracting articles.

EDUCATION, TRAINING, AND EXPERIENCE

The minimum requirement is the degree of doctor of medicine, or a doctor of philosophy degree in a biological science. Evaluating the worth and precise meaning of any published article in a scientific field of interest requires a level of knowledge that can only be acquired during the process of obtaining an M.D. or Ph.D. In addition to the advanced degree, a minimum of 2 years is required to learn the specialized applications of computers in the biological sciences, and to develop effective methods of storing and retrieving scientific prose that is qualitative as well as quantitative in nature, without altering the meaning of the author.

Nearly every department of a computer-oriented university or medical school has one of these jobs. Ordinarily, they are filled by individuals who have obtained their advanced degree at the institution where they are now assistant professors, but this is by no means a recruiting restriction. Any person with a scientific or medical doctorate who has also developed skills in semantics would be of great interest to the staff of a computer-oriented university.

WORKER TRAITS

Aptitudes:

Verbal ability to utilize the terminologies of medicine and mathematics, and to analyze the semantic aspects of word usages in medical research.

Clerical perception to detect and correct errors in abstracted data, and to read and correct computer entries shown on video screen.

Interests:

A preference for activities that are abstract and creative in nature, to apply principles of semantics and computer techniques to medical research problems, in order to develop new concepts and methods of condensing data for computer use.

Temperaments:

Must be able to observe precise standards of advanced mathematics and computer operations to develop and test methods of storing research data in computer. Must make judgmental decisions in developing glossaries and in selecting single words to substitute for meanings of phrases in abstracting data for computer use. To apply computer techniques and principles of semantics to conversion of research data to computer file.

Physical Demands and Working Conditions:

Work is sedentary.

Reaching and handling books, documents, and research material; fingering to operate keyboard of computer video screen console.

Talking and hearing to instruct students, direct subordinates, and confer with colleagues concerning academic or research matters.

Near visual acuity and accommodation to read research material and subsequent abstracts designed for computer use, and to read and correct errors noted on the video screen.

Instructor, Research, using keyboard and light pen to add new report to computer map showing incidence of diseases.

INSTRUMENT TECHNICIAN

829.281

OCCUPATIONAL DEFINITION

Tests, repairs. maintains, and modifies medical instruments and equipment, such as automatic blood pressure monitors, respirometers, audiometers, and serum auto-analyzers, using handtools, testing instruments, and following manufacturers' specifications; and modifies instruments to permit direct recording of instrument readings into computer:

Tests equipment for conformance to specified voltage, frequency, and other electrical characteristics, using oscilloscope, radio frequency meters, and other testing devices. Inspects equipment for quality of soldering, cracks, or flaws in hoses or bellows, excessive wear, and similar defects. Disassembles defective equipment, using handtools. Test accuracy of all instruments at specified intervals, and calculates mean values and standard errors for use in recording instrument readings.

Modifies components of automatic blood pressure monitors and respirometers to permit testing of different patients in rapid sequence.

Studies clinic instrumentation and equipment to devise plans for analog to digital conversion of instrument readings; and plans and tests methods of converting instrument readings directly to computer language for online recordings, using knowledge of computer flowcharts and programing techniques.

EDUCATION, TRAINING, AND EXPERIENCE

Two years of college are mandatory, with courses emphasizing electrical and electronic theories. Minimum experience is either 2 years in the Armed Forces with work assignments heavily concentrated on the repair and maintenance of medical instruments, or 4 years with a company that manufactures and repairs medical instruments.

WORKER TRAITS

Aptitudes:

Verbal ability to read and apply technical electrical and electronic texts to the assembly or repair of equipment, and to read and utilize programing logic. Spatial perception to visualize relationships between components of instruments, as indicated in rough layouts or technical diagrams.

Clerical perception to read manufacturers' instructions without perceptual errors, and to convert computer flowcharts to symbolic codes. Manual dexterity to disassemble and reassemble medical instruments.

Interests:

An interest in working with things and objects is required in maintaining and repairing medical instruments. The worker also obtains considerable satisfaction from the tangible results of his efforts.

Temperaments:

Worker relies on professional judgment to plan modifications of instruments and to design new equipment to achieve specified purpose.

Repair and fabrication of medical equipment must meet exacting standards of performance, and the work involved in writing programs to test equipment connections to computer must meet the standards of precision required in all programing.

Physical Demands and Working Conditions:

Work is light, requiring frequent walking to various sites of clinic, and frequent lifting and carrying of repair tool kit. weighing approximately 10 pounds.

Reaching, handling, and fingering are required to disassemble and reassemble medical instruments, using handtools.

Visual acuity is required to read instrument recordings, manufacturers' diagrams and drawings, and programing flowcharts. Depth perception required in assembling instruments, and color vision is necessary to distinguish color-coded wires.

MANAGER, COMPUTER CENTER

169.168

OCCUPATIONAL DEFINITION

Directs and coordinates methods of utilizing computer systems for the storage and retrieval of medical and administrative data in a medical center:

Confers with physicians, paramedical and research personnel, and hospital administrators to plan specific projects, such as the conversion of laboratory or physical examination findings to computer system; or the development of techniques to abstract and program specified heart disease data. Studies clinic procedures concerned with obtaining and recording medical information about patients, and devises recommendations for standardization of computer input data. Directs Programers' preparation of medical information program flowcharts and plans subsequent conversion of data to computer format, utilizing professional judgment to select appropriate symbolic language.

Directs, through subordinates, operating procedures in central computer room. Confers with medical personnel to improve utilization of central equipment and remote input-output terminals located throughout medical facility, and to resolve problems of computer timesharing of online operations, or personnel procedures in transmitting offline data. Assists in orientation of medical personnel in computer science and applications. Confers with management to establish priorities of computer projects.

Plans budget for operation of computer center and equipmen located at remote terminals, and submits it to management for approval. Interviews and hires new employees in computer center, approves pay raises and promotions, and discharges unsatisfactory workers.

EDUCATION, TRAINING, AND EXPERIENCE

A bachelor's degree in any of the life sciences, plus graduate-level courses in mathematics and statistics. An approximate total of 1 year of hospital experience in performance of almost any ward or clerical duties is essential to gain the background information needed by this worker. This experience can be part time and gained during school years.

With background knowledge of hospital procedures, 3 to 5 years of programing and program-compiling experience are required to learn the various basic program languages and to master the techniques of assembling a new language. Six months to a year of on-the-job experience is needed to master the intricacies of the company's present systems and plans for newer ones.

WORKER TRAITS

Aptitudes:

Verbal—to translate technical terminology into terms understandable to medical personnel, and to translate their intentions to computer personnel. Numerical—to apply advanced mathematics in the planning and evaluation of various computer programs.

Clerical perception to avoid errors in rapid reading of computer programs and printouts.

Interests:

An interest in scientific and technical subjects to understand and cope with the subject matter of medical research areas and clinical information about patients, coupled with a liking for business contacts with medical personnel and subordinate supervisors.

Temperaments:

Worker plans, directs, and controls the operation of a medical institution's computer center. Numerous conferences and meetings are required with medical and technical personnel in which information must be exchanged promptly and accurately. Worker relies on professional judgment to determine equipment needs and broad allocations of computer processing time, in order to process numerous kinds of data with varying priorities of importance. Worker also makes numerous decisions based on factual data, as shown by results of test programs, results of programing inadequate data, and similar factors.

Physical Demands and Working Conditions:

Work is mainly sedentary, but occasional walking to computer room or to various hospital locations is required. Occasional lifting of computer

run books, weighing less than 10 pounds, to examine printouts is necessary.

Talking and hearing is essential in communication with medical and computer personnel. Near visual acuity and accommodation are necessary to review statistical data and interpret charts and diagrams.

MEDICAL ANALYST-PROGRAMER Administrative Analyst

020.168

OCCUPATIONAL DEFINITION

Analyzes clinical laboratory methods and reporting procedures to formulate computer programs for storing and retrieving test data:

Studies test reporting procedures to ascertain type of laboratory analyses to be performed and deadlines for reporting routine studies.

Confers with laboratory heads to define and refine both constant and variable test report data, such as amount of hemoglobin in blood sample or the bacteriological findings of a specimen studied at 24-hour intervals.

Prepares diagram showing steps involved in various tests, and develops mathematical equations representing test results, showing relationships of constants, variables, alternatives, and other test components. Plans programing for computer language, or refers mathematical model to data-processing personnel.

Conducts trial runs of programs, and confers with data-processing personnel to correct errors.

Studies test routing procedures to ascertain the wards, clinics, and surgeries that must receive routine and emergency reports before proceeding wih patient treatment. Develops new routing procedures for medical personnel requesting laboratory studies and for laboratory personnel reporting results, based on speed and direct communication facilities of computer and related video screens and high speed printers. Conducts trial runs of new routing procedures to verify accuracy of data and timeliness of reporting.

Plans revisions and modifications of data-processing procedures to reflect changes in laboratory tests or test methods.

EDUCATION, TRAINING, AND EXPERIENCE

The minimum academic requirement is a master's degree in mathematics. This should be accompanied by at least 5 years of data-processing systems analyses, 1 year of which must be devoted exclusively to medical applications of computer systems. The 1 year of experience with medical systems is never waived, no matter how great the demand for these workers might be or how skilled the applicant may be in business systems.

WORKER TRAITS

Aptitudes:

Verbal ability to learn mathematical, medical, and laboratory terminologies.

Numerical ability to devise and apply differential equations and other advanced mathematical techniques.

Spatial ability to plan diagrams representing the flow of requests from medical personnel throughout hospital and clinic to the laboratory, and the resulting flow of emergency and routine data from the laboratory.

From perception to identify, at a glance, the symbols utilized in programing and in higher mathematics.

Interests:

A preference for technical activities to study the methods involved in medical and laboratory testing.

A preference for abstract ideas is required to plan new computer-oriented reporting systems.

Physical Demands and Working Conditions:

Work is sedentary, with occasional walking to laboratory or hospital areas.

Reaches for and handles laboratory reports, flowcharts, coding sheets, and reference texts.

Talking and hearing required to discuss medical aspects and reasons for procedures necessary in laboratory work.

Near visual acuity required to read and write mathematical formulas and coding.

MEDICAL CODING CLERK
219.382

OCCUPATIONAL DEFINITION

Converts medical research data into computer codes, keypunches information onto punchcards, and reviews subsequent computer printouts of information to detect and correct coding errors:

Obtains electronic recording tapes used in experiment, research logbook, and other data from personnel engaged in medical research, and reviews the information to ascertain the purpose of the experiment, and to note any technical difficulties encountered, for use in subsequent interpretation of computer printout. Abbreviates and lists the significant research observations specified by the investigator, such as the patient's responses, motions, or states of sleep, for conversion to computer codes.

Obtains data from computer personnel concerning amplitude of elec-

tronic impulses pertinent to whatever computer program was utilized in recording the experimental data from the laboratory. Codes these amplitude numbers, the research experiment number, the headings and parameters required, tape channels used, experimental difficulties encountered, and the research data, utilizing program code book. Records coded data on computer loadsheet. Operates keypunch to copy codes from loadsheet onto punchcard and routes cards and tapes to computer personnel for processing.

Reviews computer printout of experiment for errors due to keypunched instructions to computer, or to omissions of original data. Corrects errors and keypunches new cards. Occasionally assists medical investigator or Programer in planning and coding new or modified programs for medical research experiments.

EDUCATION, TRAINING, AND EXPERIENCE

Graduation from high school is desirable; either high school or business school training in keypunch operation is mandatory. Three months of on-the-job training are provided by supervisor of computer personnel, and worker is closely supervised for the next 3 months.

WORKER TRAITS

Aptitudes:

Verbal facility to understand terminologies, mnemonic devices, and symbols used in medical research and in computer coding.

Clerical perception to extract pertinent words and numbers from data and to read program code book instructions rapidly and accurately.

> (It should be noted that while the coding and keypunching aspects of this job are routine tasks, obtaining and abstracting the data requires initiative and intelligence, because no two experiments are alike and no two medical research investigators follow the same system of research notations.)

Interests:

Preference for activities dealing with things and objects in abstracting information from records and keypunching it onto cards. Worker also enjoys the satisfaction of correcting errors and seeing the final, finished form of the computer products.

Temperaments:

Must follow instructions closely, but these instructions vary widely, depending on the medical investigator and the type of experiment being coded. Unlike the coding clerk jobs in business and industry, this job does not typically include repetitive tasks, nor are they completed quickly.

Physical Demands and Working Conditions:

Work is sedentary.

Reaches for and handles notebooks, logbooks, coding sheets, and other forms.

Fingers switches and keys of keypunch machine.

Near visual acuity to read handwritten notes and to write, type, and correct numerical codes.

MEDICAL LABORATORY ASSISTANT II

078.584

OCCUPATIONAL DEFINITION

Prepares patient specimens for chemical, serological, or hematological tests in clinical laboratory and performs related duties as instructed by Laboratory Director:

Centrifuges blood samples and pours sera into sterile vials, using aseptic technique. Assigns patient specimen number from log book, labels serum, and copies number onto prepunched data-processing cards for subsequent recording of test results. Places numbered specimen fluids in testing racks, and compares labels with printout list of patients' identification numbers to assure accurate identification. Fills automatic pipettes with prescribed amounts of diluents for use in automatic testing machines. Loads racks of specimen fluids into autoanalyzer and starts machine. After test, transfers sera to specified vials, labels them, and stores vials in freezer. Spreads drop of patient's blood sample on microscope slide, as directed, for subsequent staining and microscopic examination. Copies test results from Medical Technicians' logbook to mark-sensed cards for use by data-processing personnel.

EDUCATION, TRAINING, AND EXPERIENCE

A twelfth grade education is required, and 1 year of job experience, under close supervision, is necessary to train workers. No previous experience is necessary.

WORKER TRAITS

Aptitudes:

Clerical perception to read and copy names and numbers rapidly and accurately.

Finger dexterity to handle test tubes and microscope slides during preparation of specimens for testing.

Manual dexterity to lift, carry, and place racks of tubes as directed and to pour diluents into automatic pipettes.

Interests:

A preference for handling laboratory equipment and supplies in a routine, organized manner.

Temperaments:

Must adapt to performing routine tasks, following explicit directions, usually completing each assignment in less than 30 minutes. Extreme care must be used to avoid errors in labeling specimens, both in the laboratory and in the storage freezers.

Physical Demands and Working Conditions:

Work is light, involving standing and walking a major part of the day.

Reaches for and handles test tubes, specimen jars, microscope slides, and data-processing cards. Finger dexterity is required to prepare microscope slides for examination.

Near visual acuity to read labels, numbers, and logbooks.

MEDICAL RECORDS LIBRARIAN

100.388

OCCUPATIONAL DEFINITION

Supervises clerical workers who compile and code medical records of hospital and clinic patients for subsequent computer programing:

Reviews clinical records of recently discharged patients, and notes information missing from charts, such as final diagnosis, pathology report, or laboratory findings. Directs subordinates to contact specified medical; laboratory, or nursing personnel to obtain data. Directs the classification of various information in completed charts, such as patient's age, symptoms, and diagnosis, into standard medical records codes, utilizing reference material. Resolves problems of interpretations of statements in charts, applying knowledge of customary medical use of language. Trains subordinates to convert standard classification codes and other specified data to computer program codes, using code book and prescribed worksheet. Approves worksheets, and routes them to keypunch personnel for processing. Reviews subsequent computer printouts of data for accuracy.

Confers with physicians to clarify their requests for data stored in computer, or to expedite service in obtaining specified groups of patient charts. Accepts legal summons to appear in court to present requested medical information. Reviews record to select pertinent information, and obtains computer printout, abstracts data, or routes selected pages of patient's chart to clerical personnel for copying. Testifies in court concerning the veracity of chart information.

Prepares monthly reports on incomplete medical records for use by hospital executives. Prepares monthly summary of medical records section activities, showing costs of personnel, materials, and time required for various types of clerical work, for use by DIRECTOR, MEDICAL DOCUMENTS in determining chargeable costs to hospital departments.

EDUCATION, TRAINING, AND EXPERIENCE

Academic requirements consist of 2 years of university liberal arts programs, followed by the 2-year training required for MEDICAL RECORDS LIBRARIANS. Certification as a Registered Record Librarian is also required. Two years' experience in a medical records department is necessary to gain sufficient working knowledge for this computer-oriented job, during which at least one course in computer programing should be taken. Three months of on-the-job training are then provided by the head of the medical records department.

WORKER TRAITS

Aptitudes:

Verbal ability to understand and to abstract significant data from pages of various medical writings in a patient's chart.

Clerical ability to review coded data rapidly and accurately and to note errors in spelling.

Interests:

A preference for business contact with others, to confer with medical personnel concerning data recorded in charts, and to train subordinates in coding techniques.

Temperaments:

Must use professional judgment to determine significant points in medical reports and histories; and to select pertinent data from charts for submission to the courts. Must observe precise standards of spelling, word usage, and coding techniques when converting data to program code.

Physical Demands and Working Conditions:

Work is sedentary. Occasional lifting of computer runbooks weighing less than 10 pounds is necessary.

Reaches for and handles patients' charts, coding sheets, printouts, and reference volumes. Near visual acuity is required to read a variety of handwritten documents in patients' charts and to review computer coding sheets for accuracy.

MEDICAL RECORD PROGRAMER-ANALYST

020.168

OCCUPATIONAL DEFINITION

Directs conversion of medical records data to computer language and supervises workers engaged in converting medical information to computer codes.

Confers with DIRECTOR, MEDICAL DOCUMENTS to resolve semantic difficulties noted in recorded information. Confers with Programer and Systems Analyst to devise alphabetical and numerical codes for computer tabulation of patient data, showing number of hospital patients, births, deaths, days of hospital care per patient, and other statistical information, utilizing knowledge of programing techniques and medical records procedures. Plans and directs the subsequent clarification and coding of incoming charts. Develops computer subroutines to obtain data already filed in computer, such as the nursing service workload during various periods of time, or the number and types of patients treated by any specified physician. Writes specialized programs that will retrieve computer-filed information showing patient reactions to specified drugs, or specified elements of patients' histories, or other information requested by hospital departments, such as psychiatry or anesthesiology.

Supervises workers engaged in operating keypunch machines for conversions of programed data to computer-processable form. Determines priority of information to be converted, utilizing knowledge of hospital needs, statutory regulations, and available personnel. Plans work procedures, and assigns duties to workers. Trains workers in the use of medical references and reviews and corrects their work. Recommends the hire, promotion, or discharge of keypunch personnel.

Prepares monthly reports of programing costs, itemizing salary expenses, materials used, and time required for storage or conversion of various types of information to computer language. Submits summary to DIRECTOR, MEDICAL DOCUMENTS for determination of costs to computer users.

EDUCATION, TRAINING, AND EXPERIENCE

Minimum requirements are a bachelor's degree; certification as a Registered Record Librarian; a master's degree that includes graduate-level courses in statistics and in utilization of computers; 1 year of programing biological or medical records data; and 2 years as a MEDICAL RECORDS LIBRARIAN. One month of on-the-job training is provided by the employer. These specifications are not as difficult to meet as they might seem. Many MEDICAL RECORDS LIBRARIANS work full time for about 2 years, and then change to part-time medical records employment while they earn a master's degree. During this period, the knowledge and experience necessary for this job can be readily acquired.

WORKER TRAITS

Aptitudes:

Verbal ability to learn and use the terminologies of all medical fields, of programing, and of mathematics and computer processes.

Clerical perception to detect numerical misprints or duplications in computer printouts, and to recognize probable errors in abbreviations or other entries in patients' charts or on business office records.

Numerical ability to apply mathematical techniques to data flowcharts and to the subsequent programing.

Interests:

A preference for technical activities in preparing workflow and program formulas and reducing them to computer-processable forms.

A preference for abstract and creative activities, to devise new computer-oriented systems to meet specific medical records needs.

Temperaments:

Must make factual programing decisions on basis of computer printout errors, and observe precise standards in programing processes. Makes judgmental decisions to select most effective programing and procedural systems and to assign duties and establish priorities of work among subordinates.

Physical Demands and Working Conditions:

Work is sedentary, but involves considerable walking at times to aid subordinates or to locate data in medical records files.

Constant handling of records, printouts, programing forms, and pencils in planning program and posting codes to program sheets.

Near visual acuity to read and write computer symbols and mathematical formulas.

MEDICAL RESEARCH ASSISTANT

041.081

OCCUPATIONAL DEFINITION

Plans computer simulation of the physiological or biological responses expected during medical laboratory experiments that utilize computers; writes analog and digital programs for the experiment; and conducts trial runs of computer data to verify accuracy of programing methods.

Confers with medical research investigator to determine the specific responses to be measured, and to decide whether electronic, electrical, or

other measurements are to be used. Discusses laboratory methods planned for experiment designed to test such factors as the response of a brain cell to intensities of electrical stimulus, the effect of light on the rate of metabolism of a single cell animal, or the effect of certain chemicals on the size and growth rate of plants.

Plans mathematical design for experiment, utilizing differential equations, and other advanced techniques to represent all the variations of stimulus that will be applied during experiment, and all the conceivable biological responses that may occur as a result. Plans and writes computer program according to the mathematical design and routes it to computer personnel. Reviews and approves keypunch procedures to be followed in transferring data into computer language, and routes approved procedures to keypunch personnel for processing and subsequent transfer to computer tape.

Devises and programs series of test queries and comments to verify accuracy of information stored, and reviews results to detect erroneous computer responses. Modifies program to correct errors.

Plans and programs hypothetical combination of experimental factors that could simulate experimental results, and summarizes computer results for approval by medical research investigator. Observes subsequent laboratory experiment to convert or improve computer input or output.

EDUCATION, TRAINING, AND EXPERIENCE

The minimum requirements consist of a bachelor's degree in anatomy, biochemistry, or other biological sciences; and a master's degree in mathematics or physics. Two years of medical or biological computer programing is essential to master the intricacies of simulating a biological system. Although this is a full-time job, most workers are attending graduate school part time, either to earn a doctor's degree in the scientific specialty of their choice, or to augment their knowledge in one or two subject areas. Since the demand far exceeds the supply, recruitment for qualified individuals to fill these jobs is never limited to graduate students currently attending a university.

WORKER TRAITS

Aptitudes:

Verbal ability to utilize the terminologies of physics, mathematics, and the specific medical-biological field of specialty, such as biochemistry or anatomy. Clerical perception to read and write mathematics and computer symbols without perceptual error.

Numerical ability to apply advanced mathematics to medical probability theories.

Interests:

A preference for activities that are scientific and technical in nature, to apply analytical and quantitative techniques to medical research data, and an interest in devising mathematical equations to represent known and biological activities.

Temperaments:

Professional judgment is required in selecting or devising mathematical formulas to represent biological activity. Judgment based on factual decisions is also required in order to plan and write programs keyed to signals received from measuring devices and to the computer's own capabilities.

Must be able to observe precise standards of advanced mathematics and analog computer programs to develop and test methods of incorporating computer capabilities into research program.

Physical Demands and Working Conditions:

Work is sedentary.

Near visual acuity and accommodation are required to read graphs, tracings, and to read and write correct mathematical and computer symbols.

MEDICAL SYSTEMS ANALYST, COMPUTER

020.168

OCCUPATIONAL DEFINITION

Analyzes hospital, clinical, and research procedures involving drugs and other medications, and formulates new systems of reporting information on dosages, patient reactions, patient drug history, and other data for inclusion in computer information system:

Confers with physicians, pharmacists, and laboratory personnel to define content of required input data, such as physical or laboratory findings after administration of drugs. Observes laboratory data, nursing personnel activities, and other work procedures, and studies report forms currently in use to plan accurate and economical system of obtaining data recorded on forms suitable for conversion to computer programing. Designs punchcards and other forms for use in recording pharmaceutical information.

Plans computer program, utilizing knowledge of computer capability, data processing techniques, and medical procedures. Devises assembly language to convert data, or modifies FORTRAN or other language, and directs Programers in compiling language and converting data to machine processable form. Conducts test runs of program, and studies computer printout of results to detect and correct errors due to initial data, or to program codes.

EDUCATION, TRAINING, AND EXPERIENCE

A bachelor of science degree in mathematics is required, and a master's degree is preferred. Four to 6 years of systems programing, compiler programing, and data processing analysis is necessary, in addition to at least 2 years of assembly language programing. This experience may be gained in either business or medical fields, but there must be at least 1 year of experience in working with medical personnel to learn the medical point of view and the necessity of working with soft data such as ranges of variable numbers instead of averages.

WORKER TRAITS

Aptitudes:

Verbal ability to understand and use medical and mathematical terminologies.

Numerical ability to plan computer input systems, and computer flowchart procedures, using advanced mathematical principles and computer techniques.

Clerical perception to read program flowcharts and codes and to identify symbols and numbers accurately.

Interests:

A preference for activities that are scientific and technical, and those that are abstract and creative, to study current medical procedures and devise ways to standardize them for conversion to computer-oriented methods.

Temperaments:

Must be able to plan and direct methods of transferring data from medical history, pharmacy or ward records, or other source to computer language.

Required to confer extensively with various medical personnel to analyze their procedures and present new systems that are acceptable to them. Must rely on judgment in devising systems that will obtain and record all desired data.

Physical Demands and Working Conditions:

Work is sedentary, with occasional walking. Occasional handling of books and documents that rarely exceed 10 pounds.

Talking and hearing to confer with medical personnel to resolve systems problems.

Near visual acuity to prepare and review flowcharts and codes.

MEDICAL TECHNOLOGIST, CHIEF

078.168

OCCUPATIONAL DEFINITION

Directs and coordinates activities of medical center workers performing clinical laboratory tests and reporting results in computer format, using manual and automated equipment:

Confers with the laboratory director to plan policies of the chemistry, serology, virology, and other laboratories concerning such matters as levels of subordinate supervision, exploratory studies of new tests and equipment, or procedures to verify accuracy of tests. Establishes or approves all testing procedures, and interprets policies to subordinate supervisors.

Plans workflow for use of automated testing machines, such as auto-analyzer, or blood gas machines, and for computer peripheral equipment, such as photometric devices that convert test results to digital codes for use by computer. Confers with MEDICAL SYSTEMS ANALYST, COMPUTER and MEDICAL ANALYST-PROGRAMER and determines and approves exact data to be coded for computer use. Approves mark-sense cards and other forms to be used in reporting Laboratory results. Observes personnel to assure efficiency and ease of manual or automated test procedures, and to assure adequacy and speed of computer reporting system. Reviews daily summary of mechanical or personnel errors, and confers with subordinate supervisors to plan corrective action.

EDUCATION, TRAINING, AND EXPERIENCE

The minimum requirements consist of a bachelor of arts or a bachelor of science degree which has included or been supplemented by a clinical year in a school of medical technology accredited by the American Society of Clinical Pathologists (ASCP). The worker should also be certified or be eligible for certification as a medical technologist by the Board of Registry of the ASCP, and have had 5 years of progressively responsible experience in clinical laboratories. In addition, there must be 1 year of experience with computer software problems in the medical field, or 1 year of college-level courses in programing.

WORKER TRAITS

Aptitudes:

Verbal ability to read and apply medical and medical laboratory terminologies, and to determine exact words to be used in computer conversion of laboratory data.

Numerical ability to apply mathematics to problems in chemistry and related fields, and to work with computer flowcharts and coding problems.

Interests:

A preference for business contact with people, as shown in conferences with computer personnel and medical and laboratory personnel; and a liking for activities that are scientific and technical in nature to plan or approve laboratory or computer procedures.

Temperaments:

Direction, planning, and control of all laboratory procedures and workflow of all the laboratories. Professional judgment is required to make decisions concerning new tests or automated methods, and to determine or approve computer input language.

Physical Demands and Working Conditions:

Work is sedentary.

Talking and hearing are essential in giving instructions to subordinates

and in conferring with other hospital personnel.

Near visual acuity is required to read and analyze reports, graphs, tracings, and other laboratory data and to read computer printouts.

MEDLARS LIBRARIAN
Reference Librarian
100.168

OCCUPATIONAL DEFINITION

Studies requests from users of medical center library for published references on specified subjects, and formulates computer-processable *demand search* for information requested, using MEDLARS system:

Reviews request for information concerning a disease, syndrome, laboratory test, or other medical subject, referring to medical dictionaries to clarify terminologies used. Consults library sources of information to assure inclusion of pertinent subtopics in demand search of national and regional bibliographic listings, and to narrow search to pertinent data. Selects key words and synonyms used to describe subject, and translates them into fixed computer language vocabulary of MEDLARS, using modified compiler for COBOL or other specified computer language.

Selects high speed or logical search (principal references or all references) according to urgency of request and estimated manhours available to review subsequent computer printouts of information. Submits coded reference request to National Library of Medicine and to regional computer center. Receives computer printouts, and participates in review of citations to assure adequate fulfillment of library user's request. Writes letter describing the key words, synonyms, and search strategy used, and routes it with printouts to individuals placing request for the information.

Trains and gives work directions to other Medical Librarians engaged in writing searches for computer processing.

EDUCATION, TRAINING, AND EXPERIENCE

Minimum requirement is a bachelor of science degree in library sciences, and a master of arts or sciences in a medical or biomedical field. The MEDLARS LIBRARIAN must have a superior grasp of several medical disciplines in order to cope with reference requests for any aspect of any medical field, and to translate these requests into coded language. In addition, worker must have either past experience in programing, or college-level courses in programing techniques to learn the necessary precision of words and computer logic required for computer translations of biomedical information. Minimum prior work experience consists of 2 years as a Medical Librarian.

WORKER TRAITS

Aptitudes:

Verbal ability to master terminologies of several medical disciplines.

Clerical perception to translate English words into computer languages accurately and rapidly, and to read computer printouts for accuracy.

Interests:

A continuing interest in scientific and technical matters, to keep abreast of medical library information; and to convert medical subject matter to computer codes, making sure that all related subjects are considered.

Temperaments:

Relies on professional judgment to establish scope and limits of subject matter requested by library users; conversion of data to MEDLARS system requires logic and coding that meet very precise computer standards.

Physical Demands and Working Conditions:

Work is sedentary, with occasional standing and walking.

Reaching for, handling, and fingering documents, cards, and code sheets. Near visual acuity to read published articles, bibliographies, computer code books, and printouts.

SUPERVISING COMPUTER OPERATOR-TECHNICIAN

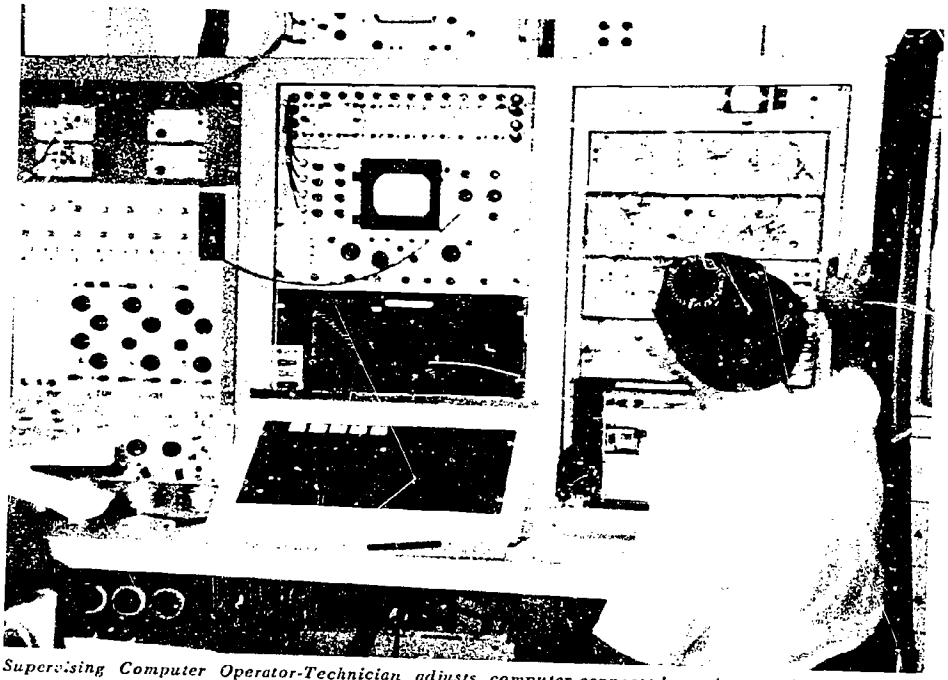
213.138

OCCUPATIONAL DEFINITION

Supervises and coordinates activities of computer operators in data processing center of medical research institute:

Assigns personnel to computers and to peripheral equipment such as electronic sorters and keypunch machines, and schedules workflow to meet planned use of computer facilities by medical research staff. Trains subordinates in operation of machines, and instructs them in medical research methods and terminologies to enable them to distinguish machine errors from improper coding or other data errors.

Reviews aims, methods, and program codes of each experiment, and develops operating methods to process medical data, such as selecting sequences of trial tests of EEG's, EKG's, temperature recordings, or other physiological measurements; or modifies console control of digital converter to receive specified analog input. Adjusts oscilloscope for specific wave rhythms, such as pulse rates or heart beats. Observes oscilloscope display of experiment, and distinguishes noise (signal interference) from significant experimental measurements, using knowledge of normal readings and purpose of experiment. Verifies suspected malfunctioning of program or equipment by processing test program comparable to recorded experiment. Evaluates test results in the light of ex-



Supervising Computer Operator-Technician adjusts computer-connected equipment in laboratory.

periment's aims, and notifies investigator of inadequate data, or directs MEDICAL CODING CLERK to correct coding errors. Contacts equipment manufacturer to correct or improve machine operations. Confers with research investigators to plan computer time-sharing procedures, and to determine most effective laboratory methods of recording physiological reaction of animals for online or offline computer analyses. Demonstrates the use of computer consoles placed in the laboratory, and clarifies the signals utilized between investigator and computer operating personnel during online operations.

Operates teletype to communicate with outlying, connected stations submitting online computer data, to resolve problems of recording or programing as shown by results of computer's online analyses.

Reads daily printouts of error listings, and analyzes probable causes, such as faulty programing or electronic signal difficulties. Confers with investigators or clerical or computer personnel to resolve problems.

EDUCATION, TRAINING, AND EXPERIENCE

Two years of college, with emphasis on mathematics and science courses, is the minimum requirement. Knowledge of the function and operation of oscilloscopes and other routine electronic laboratory equipment is also required. This knowledge can be acquired either in formal classroom work or on a job. At least 1 year of experience in operating computers and peripheral equipment in the biological sciences is essential. Business experience is *not* acceptable as a substitute, since the medical approach is entirely different and this worker is closely involved with medical and research personnel. In addition to this experience, a minimum of 6 months as a Senior Computer Operator is required to learn the kinds of problems the medical personnel face with the data they wish to com-

puterize, and to master advanced computer trouble-shooting techniques. Supervisory experience is highly desirable.

WORKER TRAITS

Aptitudes:

Verbal ability to master terminologies of medical research specialties and of electronics and computer operations.
Numerical ability to understand various programing techniques well enough to detect errors and suggest modifications.

Spatial perception to make minor adjustments of control panel wiring.

Interests:

A preference for business contact with others to confer with medical personnel and to supervise subordinates.

A preference for scientific and technical activities to keep abreast of manufacturers' changes in computer hardware; and to grasp the procedures and aims of research experiments in order to distinguish between computer errors and experimental errors.

Temperaments:

Ability to perform a variety of different tasks, such as training and assigning personnel, developing new operating procedures, changing production schedules to accommodate emergency runs, and maintaining records.

Must be able to plan, direct, and control the activities of computer operators concerned with either central or peripheral equipment.

Must deal with medical and research personnel to resolve problems of computer input and output, suitability of data, and scheduling of online computer use.

Required to make judgmental decisions in establishing schedules and work priorities to make maximum use of workers' knowledge and ability and most effective use of computers and peripheral equipment.

Must make decisions on factual basis to evaluate computer output in the light of the equipment available, and programs utilized, and to develop plans for equipment or procedural modifications to improve efficiency of operations.

Physical Demands and Working Conditions:

Work is light, requiring frequent standing and walking, and occasional lifting and handling of reels of tape, and of control panels weighing up to 10 pounds.

Fingering is required to operate keyboard.

Talking and hearing are essential to give oral instructions, assign work, train personnel, and resolve procedural problems with medical personnel. Near visual acuity is necessary to study program runbooks, read oscilloscopes, coding instructions, and records.

SUPERVISOR, COMPUTER OPERATIONS

169.138

OCCUPATIONAL DEFINITION

Supervises and coordinates activities of personnel engaged in operating data processing equipment, and assists MANAGER, COMPUTER CENTER in planning for and installing new or modified equipment:

Schedules workflow to facilitate storage of and access to computer data concerning patients, clinics, hospital departments, and research sections. Assigns personnel to operate such equipment as optical scanners, interpreters, and computers. Trains workers in the operation of equipment according to hospital's data processing procedures. Writes instructions indicating new or modified techniques to follow in operation of equipment. Troubleshoots equipment to locate causes of inadequate telecommunications, such as faulty signals from remote input-output terminals, or erroneous printouts due to faulty programing. Notifies medical personnel at terminal stations of their errors in operating input equipment and explains correct method to be used. Makes minor adjustments to processing equipment to maintain proper machine operations. Remains on call during off hours to resolve problems of work priorities, telecommunications, or equipment operations.

Confers with MANAGER, COMPUTER CENTER regarding type and source of medical data to be incorporated into computer operations and to devise plans for processing them by modifying present equipment or installing new equipment. Consults manufacturer's specifications and plans layout of equipment taking into consideration such factors as sites of proposed video screens, high-speed printers, or other equipment, air-conditioning requirements, soundproofing, and limitations of central computer equipment. Submits plans to superior for approval.

EDUCATION, TRAINING, AND EXPERIENCE

A college degree is usually required, including courses in data processing methods. Five to 7 years' experience in the operation of data processing equipment and in the supervision of personnel engaged in operating computers and peripheral equipment. This experience need not be in the medical fields, but it must include effective solutions to all the mechanical and personnel problems encountered in the operation of a computer center. One year of experience on the job is required to master the medical terminologies used, to understand the material to be programed, and to develop a working knowledge of the medical treatment and research methods characteristic of the institution.

WORKER TRAITS

Aptitudes:

Verbal ability to grasp and use the pertinent terminologies of programing, medical procedures, and computer operations.

Spatial ability to visualize the mechanical defects causing improper function of computer or peripheral equipment.

Form perception to see, at a glance, whether a punchcard or printout contains the expected numbers or letters in proper sequence.

Temperaments:

Required to plan and control the activities of personnel engaged in operating computers and related equipment. Required to make judgmental decisions when detecting and correcting errors caused either by mechanical failure or inadequate data. Worker must also function well under considerable pressure of being responsible for obtaining, or correcting, data needed for patients in critical condition.

Interests:

Interests primarily directed toward technical and scientific aspects of storing information in computer storage and retrieval of medical data, and contact with the medical staff concerning computer programs.

Physical Demands and Working Conditions:

Work is light, requiring frequent standing and walking. Occasional lifting and handling of reels of tape, decks or boxes of punchcards. and equipment panels that weigh up to 20 pounds.

Talking and hearing are essential in giving oral instructions, assigning work, and training personnel.

Near visual acuity is frequently needed to analyze programing records and computer program runbooks, and to read technical or medical data.

SUPERVISOR, IDENTIFICATION AND CENSUS

213.138

OCCUPATIONAL DEFINITION

Supervises and coordinates activities of hospital clerical workers engaged in issuing patient identification numbers; placing hospital forms in charts for new patients; operating keypunch and addressing machines; coding specified data into predetermined program codes; and typing data on computer keyboard console for online recording in computers:

Plans priorities of procedures, and assigns duties to personnel, scheduling workflow to facilitate 24-hour service. Trains workers in operation of addresso graph and computer console, and aids them in detecting and correcting errors in requisitions received from other departments for patient's name or identification number.

Obtains daily information from hospital personnel concerning admissions, discharges, births, deaths, age, and sex, and routes data to subordinates for keypunching. Reviews printouts of census data to detect errors of numbers, names, or other entries, referring to patient's chart to verify corrections.

Confers with programing personnel to develop methods of resolving persistent errors in computer printouts. Tests new computer codes and programs to detect operational flaws. Confers with Systems Analyst-Programer to develop improved methods of online filing of census and identification data. Keeps time schedules of subordinates, and recommends promotions, pay raises, and discharges.

EDUCATION, TRAINING, AND EXPERIENCE

A minimum of 2 years of college is required. Courses must include English to assure good spelling and a good grasp of the correct usage of the English language, and at least two courses in basic computer operations and programing techniques. One course in business management is required to understand the purposes of the necessary statistical information processed by hospitals. Minimum work experience consists of 6 months full-time employment in a hospital medical records department to learn the filing systems, hospital procedures, information workflows, and departmental organizations. Additional training is required from time to time, and arranged by the employer, to keep abreast of changes in hospital's data processing equipment or computer procedures.

WORKER TRAITS

Aptitudes:

Verbal ability to understand and use terminologies pertinent to hospital statistical procedures, patient identification problems, and computer operations.

Clerical perception to proofread numbers for accuracy and words or names for correct spelling.

Interests:

A preference for business contact with others to supervise subordinates.

A preference for technical activities to plan and control transfer of specified numerical data to computer printouts.

Temperaments:

Must be able to plan and control the activities of subordinates engaged in a variety of routine and emergency clerical activities.

Physical Demands and Working Conditions:

Work is light, involving standi- , at clerical machines to aid subordinates, and frequent walking to various areas of the medical records department or hospital to resolve problems or confer with superiors. Work requires occasional lifting of computer runbooks weighing less than 10 pounds.

Talking and hearing involved in instructing subordinates and in conferring with superiors and computer personnel.

Near visual acuity required to read and detect errors in printouts of census data.

Reaches for and handles medical records, requisitions, and computer printouts.
Color vision to distinguish color codes used in medical records form and in records filing system.

SUPERVISOR, KEYPUNCH OPERATIONS

Supervisor, Technical Operations

213.138

OCCUPATIONAL DEFINITION

Supervises and coordinates activities of workers operating such machines as keypunchers, reader-printers, and reproducing punches to process patients' medical and laboratory test results for immediate routing to hospital computer:

Plans worker shifts, according to peak surges of reports received from chemistry and bacteriology laboratories, and from radiology, pediatrics, and other medical departments, and determines priority of work. Writes detailed procedures for the operations of machines; for the verification of test data received, such as identification numbers of patient and of clinic or ward requesting test; and for the workflow routing of printed forms and mark-sense cards. Issues verbal orders to expedite processing of emergency reports.

Reviews computer printouts of laboratory test results for errors, such as discrepancies between laboratory specimen number and number used in code, or lack of information from outside laboratory performing listed test. Notifies laboratories of errors and files printouts.

Examines malfunctioning machines for possible obstructions, such as warped or jammed cards, or improper adjustment of dials and switches, and corrects difficulty. Notifies manufacturer of mechanical breakdown. When advised of prolonged delay for machine repair, routes workflow through other equipment, or requests laboratories to use manual reporting procedures.

Analyzes special programs of data received from medical departments for processing through computer, to determine workflow procedures and to detect such errors as inadequate program flowchart format or poor legibility. Writes report to supervisor of inadequate or incomplete data received, and recommends corrective actions.

Keeps subordinates' time schedules. Recommends promotions, pay raises, and discharges.

EDUCATION, TRAINING, AND EXPERIENCE

High school graduation is the minimum academic requirement, with courses either in high school or in a business school to learn to operate a keypunch and related computer peripheral machines. Six months' experience as keypunch operator is considered the minimum time necessary to develop speed and accuracy. In addition, 1 year of experience in a medical computer center is required to learn hospital procedures, the most efficient methods of verifying any questionable accuracy in the information received, and the management of delays. Hundreds of test results and other items of information flow through the Technical Operations Unit every day. Delays in receiving data or delays due to mechanical breakdowns create a massive jam of work that must be reorganized rapidly and efficiently.

WORKER TRAITS

Aptitudes:

Verbal ability to understand medical laboratory and clinical terminologies.

Clerical ability to read printed forms, mark-sense cards, and computer printouts rapidly, to detect errors in numbers or names.

Interests:

A preference for business contact with others, expressed in frequent contacts with laboratory personnel and subordinates; and an interest in planning and directing the operation of the computer-related data processing machines.

Temperaments:

Ability to plan the routing and processing of data through the computer's peripheral equipment, always working against time deadlines.

Ability to decide quickly and with judgment on alternate methods of processing data when there are mechanical failures or other delays.

Physical Demands and Working Conditions:

Work is sedentary.

Reaches for and handles business records, decks of punchcards, laboratory reports, and code sheets; fingers switches and keys to correct minor difficulties of malfunctioning machines.

Near visual acuity to read codes, flowcharts, and handwriting.

SYSTEMS AND PROCEDURES ANALYST, COMPUTER

161.268

OCCUPATIONAL DEFINITION

Plans nonmedical procedures in hospitals and clinics to improve the efficiency of collecting information, improve service, and decrease costs:

Observes workflow and confers with medical and clerical personnel to evaluate such procedures as scheduling and routing of patients, abstracting data from patient's questionnaire or other medical records, and recording and routing data to patient's chart and to computer processing personnel.

Prepares procedural chart of information flow and analyzes it to ascertain causes for delays and omissions or duplications in recording and routing patient information. Studies forms in current use for recording patient's clinical findings and other data, and confers with physicians to define the required data, and with computer specialists to learn of the limitations imposed by conversion of information to computer system. Confers with paramedical personnel concerning current procedures of recording laboratory, X-ray, and other findings onto forms, and plans methods of eliminating duplication and standardizing information. Devises new, modified, or consolidated forms to be used by patients and personnel, considering such additional factors as precision of language necessary for computer use, relation of information under study to other hospital records, and clerical processing time. Submits forms to hospital management for approval. Writes and updates manual of procedures for use in training workers to utilize new procedures.

Studies effect of new procedures on information system to detect any related difficulties, such as inadequate work areas, poor structural layout, or inefficient placement of telephones and intercom systems. Recommends corrective changes to management.

Reads professional journals, confers with vendors, and attends conferences to keep abreast of developments in data processing, records administration, documentation, and hospital management trends.

EDUCATION, TRAINING, AND EXPERIENCE

Minimum academic requirement is either a bachelor's degree in business administration, or a master's degree in hospital administration. Either undergraduate writing courses, or published papers, are required to establish writing skills. In addition to any possible business experience the worker may have, there must be at least 2 years of systems

analysis in a medical institution to learn the kinds of information that are customarily required in the treatment of patients.

WORKER TRAITS

Aptitudes:

Verbal ability to utilize the terminologies of medicine and business administration in the analysis of old forms and development of new ones.

Spatial perception to visualize dimensions of structures and equipment as they pertain to information workflow, and to develop flowcharts specifying effective sequences of data recording and routing.

Clerical perception to avoid errors in reading and reorganizing the information stated on forms.

Interests:

A preference for activities that involve business contact with medical and administrative personnel, together with a marked interest in clear, technical writing.

Temperaments:

Job duties require considerable cooperation with, and from, medical and administrative personnel in order to develop accurate, efficient workflow that is acceptable to the workers. Professional judgment is required to analyze difficulties of data recording or routing, and to plan new systems that will solve these problems without creating new ones.

Physical Demands and Working Conditions:

Work is usually sedentary, but there may be periods of weeks when worker must constantly walk and stand, to observe and analyze departmental work procedures.

Talking and hearing are essential in conferences with medical and paramedical personnel concerning the present procedures and proposed changes.

Near visual acuity is necessary to study forms, charts, graphs, and other data utilized by personnel; and to draw flowcharts and diagrams of procedural activities of department being studied.

GLOSSARY

GLOSSARY

A

ANALOG COMPUTER: An electronic calculating machine that measures and compares continuous variables, such as scale lengths or blood pressures, using mathematical analogies to electrical variables, such as voltage and current. For addition and multiplication, a special circuit feeds in specified voltages. Analog computers are used in online medical research and in many clinical applications wherein numerous variables must be measured simultaneously.

C

COBOL: Acronym for Common Business Oriented Language. Formulated originally for business and commercial use, it lends itself to modification in some medical areas of interest.

COMPILER: A computer program that translates symbolic operation codes into machine instruction and also replaces specified items of input with further instructions.

COMPUTER: An electronic calculating machine that manipulates mathematical symbols at high speed. The machines are designed for extremely complicated processings of groups of symbols that serve as codes for any groups of data desired. Specific machine instructions for each manipulation always form part of the program.

D

DEMAND SEARCH: A phrase used by reference librarians to indicate subject matter, subtopics, and related information needed to search a complete file of publications to obtain the titles of all articles pertaining to the request of the library user.

DIGITAL COMPUTER: An electronic calculating machine that solves mathematical problems by precise and sequential counting at high speed with the numbers coded to represent specified data. The digital computer is used in programing solutions of problems involving many logical decisions; or for rearranging constant data, such as patients' weights, ages, and diseases, to investigate possible relationships. Digital computing techniques are required for storage and retrieval of data.

F

FORTRAN: Acronym for FORmula TRANslator. A program language designed for problems which can be expressed in algebraic notation.

I

INDEX MEDICUS: A bibliography of articles appearing in current medical science journals, compiled and published monthly and annually.

L

LOGICAL EXPRESSION: Computer program-phrasing that involves the use of nouns separated by the conjunctions ("and," "or") or

their negations ("not" and "not or"), together with instructions for computer manipulation of the subsequent search for matching nouns.

M

MARK-SENSE CARD: A punchcard with printed words showing multiple choices of information. Worker selects appropriate word to be punched and marks it with a pencil. This information is then automatically punched or converted to tape for direct processing into computer.

MATHEMATICAL MODEL: A body of mathematical statements describing a process or concept that is analogous to an observed process or concept. The model permits manipulation of variables, which is useful in estimating the probable behavior of actual processes.

MEDLARS: Acronym for MEDical Literature Analysis and Retrieval Systems. This computer system was designed specifically for searches of bibliographic material that is filed by author, title, and subject matter in the National Library of Medicine, Washington, D.C.

MEMORY: Data entered in any digital computer that remains after a mathematical manipulation. The data can be "erased" readily or transferred to STORAGE for future use.

O

ONLINE: Direct electronic communication between any terminal in the computer system and the central processing unit.

P

PARAMETER: A constant or a variable in mathematics that remains unchanged during a specified calculation.

S

SIGNIFICANT ELEMENTS: Programed words and phrases that serve as retrieval criteria in high speed, gross screening of computerized bibliographies.

SIMULATION: Mathematical or other symbolic representation of the key elements of an object, system, phenomenon, or environment.

SIMULATOR: A model of a system or phenomenon that simulates the effects of various changes in the original, enabling the researcher to study, analyze, and understand the original by controlling changes in the behavior of the model. Simulators usually are three-dimensional and constructed to look like the original.

SOFTWARE: All the programs and related methods required to record and manipulate data in a computer.

STORAGE: Any device used to store information, such as the magnetic core or disc storage, ultrasonic delay line, drum memory, or magnetic film memory.

ON THE HORIZON --- EQUIPMENT THAT THINKS

Now being developed at the University of Southern California is a "machine" that learns and remembers data in a manner strikingly similar to human learning. It recalls, and reacts to, forms, shapes, and signals; and it develops logical thought patterns. It even grows forgetful when overworked, and shows signs of fatigue that disappear after a brief rest.

There are no wires in this "machine" or "brain." Instead, tiny particles of iron, gold, silver, and other substances are immersed in nitric acid, where they form tree-like shapes called dendrites. When electricity passes through the acid, shock waves alter the shape of the dendrites slightly, in much the same way that brain cells respond to stimuli. Subsequent electrical current passing through these dendrites becomes slightly modified because of the alteration of the dendrites. This dendritic change can be cancelled by a controlled jolt of electricity, but the shock affects only the changes created by the preceding stimulus.

By applying selective electrical stimuli and shocks, the shape of the dendrites—and hence the reaction of the electrical current—is modified, just as a small child's behavior is modified by spankings. As the modifications progress, the dendrites "learn" to respond to fairly complex stimuli.

Once trained, this electromechanical combination can recognize patterns, or distinguish between sizes and shapes, or react both negatively and positively to various combinations of sounds and lights, or appearances and weights.

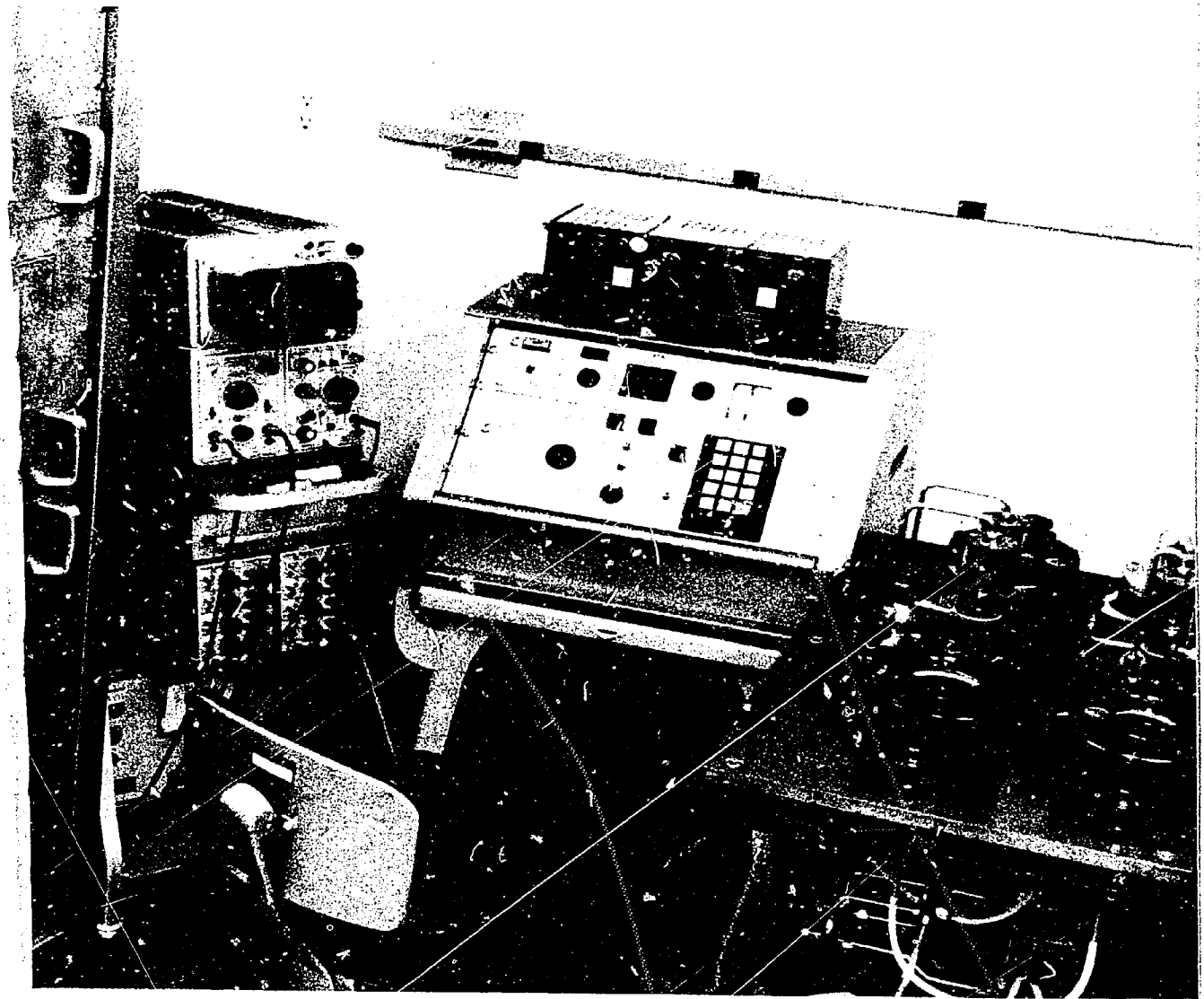
Potential applications of this device to military and business needs are endless. Watching a radar screen to distinguish friendly and enemy "blips" is one example; inspection of the appearance of lacquered finishes or fresh fruit are others. In the medical health sciences, this kind

of "brain" would create many occupational changes. Many kinds of drudgery would be eliminated, and a great many repetitive tasks would no longer require human attention. (Scanning routine X-rays for evidence of lung disease, for example.)

In conjunction with the electronic computers, the "brain" will open new doors in research and clinical applications and abolish some of the present clerical needs.

On the other hand, new occupations will have to emerge in connection with utilizing this invaluable assistance, and the jobs necessarily will range—as they do with electronic computers—from the very complex to the relatively simple.

Experimental model of "Thinking Machine." Dendrites are located in circular containers on table.



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APPENDIX

Worker Traits

APPENDIX

Worker Traits

APTITUDES:

VERBAL. Ability to understand meanings of words and ideas associated with them, and to use them effectively; to comprehend language, to understand relationships between words, and to understand meanings of whole sentences and paragraphs; to present information or ideas clearly.

NUMERICAL. Ability to perform arithmetic operations quickly and accurately.

SPATIAL. Ability to comprehend forms in space and understand relationships of plane and solid objects. May be used in such tasks as blueprint reading and in solving geometry problems. Frequently described as the ability to "visualize" objects of two or three dimensions, or to think visually of geometric forms.

FORM PERCEPTION. Ability to perceive pertinent detail in objects or in pictorial or graphic material; to make visual comparisons and discriminations and see slight differences in shapes and shadings of figures and widths and lengths of lines.

CLERICAL PERCEPTION. Ability to perceive pertinent detail in verbal or tabular material; to observe differences in copy; to proofread words and numbers; and to avoid perceptual errors in arithmetic computation.

MOTOR COORDINATION. Ability to coordinate eyes and hands or fingers rapidly and accurately in making precise movements with speed; to make a movement-response accurately and quickly.

FINGER DEXTERITY. Ability to move the fingers and manipulate small objects with the fingers rapidly and accurately.

MANUAL DEXTERITY. Ability to move the hands easily and skillfully; to work with the hands in placing and turning motions.

EYE-HAND-FOOT COORDINATION. Ability to move the hand and foot coordinately with each other in accordance with visual stimuli.

COLOR DISCRIMINATION. Ability to perceive or recognize similarities or differences in colors, or in shades or other values of the same color; to identify a particular color, or to recognize harmonious or contrasting color combinations, or to match colors accurately.

INTELLIGENCE. General learning ability. Ability to "catch on" or understand instructions and underlying principles; to reason and make judgments; closely related to doing well in school.

INTERESTS:

1. Situations involving a preference for activities dealing with things and objects.	vs.	6. Situations involving a preference for activities concerned with people and the communication of ideas.
2. Situations involving a preference for activities involving business contact with people.	vs.	7. Situations involving a preference for activities of a scientific and technical nature.
3. Situations involving a preference for activities of a routine, concrete nature.	vs.	8. Situations involving a preference for activities of an abstract and creative nature.
4. Situations involving a preference for working for people for their presumed good, as in the social welfare sense, or for dealing with people and language in social situations.	vs.	9. Situations involving a preference for activities that are nonsocial in nature, and are carried on in relation to processes, machines, and techniques.
5. Situations involving a preference for activities resulting in prestige or the esteem of others.	vs.	10. Situations involving a preference for activities resulting in tangible productive satisfaction.

TEMPERAMENTS:

1. Situations involving a variety of duties often characterized by frequent change.
2. Situations involving repetitive or short-cycle operations carried out according to set procedures or sequences.
3. Situations involving things only under specific instruction, allowing little or no room for independent action or judgment in working out job problems.
4. Situations involving the direction, control, and planning of an entire activity or the activities of others.

5. Situations involving the necessity of dealing with people in actual job duties beyond giving and receiving instructions.

6. Situations involving working alone and apart in physical isolation from others, although activity may be integrated with that of others.

7. Situations involving influencing people in their opinions, attitudes, or judgments about ideas or things.

8. Situations involving performing adequately under stress when confronted with the critical or unexpected or when taking risks.

9. Situations involving the evaluation (arriving at generalizations, judgments, or decisions) of information against sensory or judgmental criteria.

0. Situations involving the evaluation (arriving at generalizations, judgments, or decisions) of information against measurable or verifiable criteria.

X. Situations involving the interpretation of feelings, ideas, or facts in terms of personal viewpoint.

Y. Situations involving the precise attainment of set limits, tolerances, or standards.

PHYSICAL DEMANDS FACTORS:

1. Lifting, Carrying, Pushing, and Pulling. These are the primary "strength" physical requirements, and, generally speaking, a person who engages in one of these activities can and does engage in all. Specifically, each of these activities can be described as:

Lifting—Raising or lowering an object from one level to another; includes upward pulling.

Carrying—Transporting an object, usually holding it in the hands or arms, or on the shoulder.

Pushing—Exerting force upon an object so that the object moves away from the force. This includes slapping, striking, kicking, and treadle actions.

Pulling—Exerting force upon an object so that the object moves toward the force; includes jerking.

The five degrees of physical activities factor No. 1 are as follows:

(a) Sedentary Work—Lifting 10 pounds maximum and occasionally lifting and/or carrying articles, such as dockets, ledgers, and small tools. Although a sedentary job is defined as one which involves sitting, a certain amount of walking and standing often is necessary in carrying out job duties. Jobs are rated sedentary if walking and standing are required only occasionally and all other sedentary criteria are met.

(b) Light Work—Lifting 20 pounds maximum with frequent lifting and/or carrying of objects weighing up to 10 pounds. Also, even though the weight lifted may be only a negligible amount, a job is rated in this category (1) when it requires walking or standing to a significant degree; or (2) when it requires sitting most of the time but entails pushing and pulling of arm and/or leg controls.

(c) Medium Work—Lifting 50 pounds maximum with frequent lifting and/or carrying of objects weighing up to 20 pounds. Consideration (2) under light work may apply here.

(d) Heavy Work—Lifting 100 pounds maximum with frequent lifting and/or carrying of objects weighing up to 50 pounds.

(e) Very Heavy Work—Lifting objects in excess of 100 pounds with frequent lifting and/or carrying of objects weighing up to 50 pounds or more.

2. Climbing and/or Balancing. These activities are defined as follows:

Climbing—Ascending or descending ladders, stairs, scaffolding, ramps, poles, ropes, and the like, using feet and legs and/or hands and arms.

Balancing—Maintaining body equilibrium to prevent falling when walking, standing, crouching, running on narrow, slippery, or erratically moving surfaces; or maintaining body equilibrium when performing gymnastic feats.

3. Stooping, Kneeling, Crouching and/or Crawling. These activities are defined as:

Stooping—Bending the body downward and forward by bending the spine at the waist.

Kneeling—Bending the legs at the knees to come to rest on the knee or knees.

Crouching—Bending the body downward and forward by bending the legs and spine.

Crawling—Moving about on the hands and knees or hands and feet. The activities in this factor involve full use of the lower extremities as well as the back muscles. Therefore, stooping rarely is rated when the worker is performing this act while in a sitting position.

4. Reaching, Handling, Fingering and/or Feeling. These activities involve the use of one or both of the upper extremities and are defined as follows:

Reaching—Extending the hands and arms in any direction.

Handling—Seizing, holding, grasping, turning, or otherwise working with the hands or hand (fingering not involved).

Fingering—Picking, pinching, or otherwise working with the fingers primarily (rather than with the whole hand or arm as in handling).

Feeling—Perceiving attributes of objects such as size, shape, temperature, or texture by means of receptors in the skin, particularly those of the finger tips.

5. Talking and/or Hearing. These activities are defined as follows:

Talking—Expressing or exchanging ideas by means of spoken words.

Hearing—Perceiving the nature of sounds by the ear.

The ability to talk is important for those job-worker situations in which the individual must impart oral information to clients or to the public, and in those situations in which he must convey detailed or important spoken instructions to other employees accurately, loudly, or quickly.

Hearing is important for those job-worker situations which require the ability to receive detailed information through oral communication, and to make fine discriminations in sounds, such as making fine adjustments on running engines.

6. Seeing. Seeing is the ability to perceive the nature of objects through the eye. The more important aspects of vision are: (1) acuity, far or near; (2) depth perception; (3) field of vision; (4) accommodation; and (5) color vision. These aspects of vision are defined as follows:

Acuity—far is sharpness of vision at a distance of 20 feet or more.

Acuity—near is sharpness of vision at 20 inches or less.

Depth Perception is three-dimensional seeing and is an important factor in judging distances and space relationships so as to see objects where and as they actually are. Two-eyed vision is involved here.

Field of Vision is the area that can be seen up or down or to the right or left while the eyes are fixed on a given point.

Accommodation is the adjustment of the lens of the eye to bring an object into sharp focus. This item is especially important when doing near-point work at varying distances from the eye.

Color Vision is the ability to identify and distinguish colors.

WORKING CONDITION FACTORS:

1. Work Location

Inside—Protection from weather conditions but not necessarily from temperature changes.

Outside—No effective protection from weather. Inside is rated if the worker spends approximately 75 percent or more of his time inside. Outside is rated if the worker spends approximately 75 percent or more of his time outside. Those job-worker situations which may occur inside or outside are rated "B."

2. Extreme Cold With or Without Temperature Changes. These conditions are defined as follows:

Extreme Cold—Temperature sufficiently low to cause marked bodily discomfort unless the worker is provided with exceptional protection.

Temperature Changes—Variations in temperature which are sufficiently marked and abrupt to cause marked bodily reactions.

3. Extreme Heat With or Without Temperature Changes. These conditions are defined as follows:

Extreme Heat—Temperature sufficiently high to cause marked bodily discomfort unless the worker is provided with exceptional protection.

Temperature Changes—Variations in temperature which are sufficiently marked and abrupt to cause bodily reactions.

4. **Wet and/or Humid.** These conditions are defined as follows:

Wet—Contact with water or other liquids.

Humid—Atmospheric condition with moisture content sufficiently high to cause marked bodily discomfort.

5. **Noise and/or Vibration.** For this factor to be rated, there must be sufficient noise, either constant or intermittent, to cause marked distraction or possible injury to the sense of hearing and/or sufficient vibration (which is the production of an oscillating movement or strain on the body or its extremities from motion or shock) to cause bodily harm if endured day after day.

6. **Hazards.** This category includes a variety of industrial hazards, such as proximity to moving mechanical parts, electrical shock, working on scaffolding and high places, exposure to burns and radiant energy, and exposure to all types of explosives, all of which involve the risk of bodily injury.

7. **Fumes, Odors, Toxic Conditions, Dust, and Poor Ventilation.** These conditions are grouped because they all affect the respiratory system or the skin and are defined as follows:

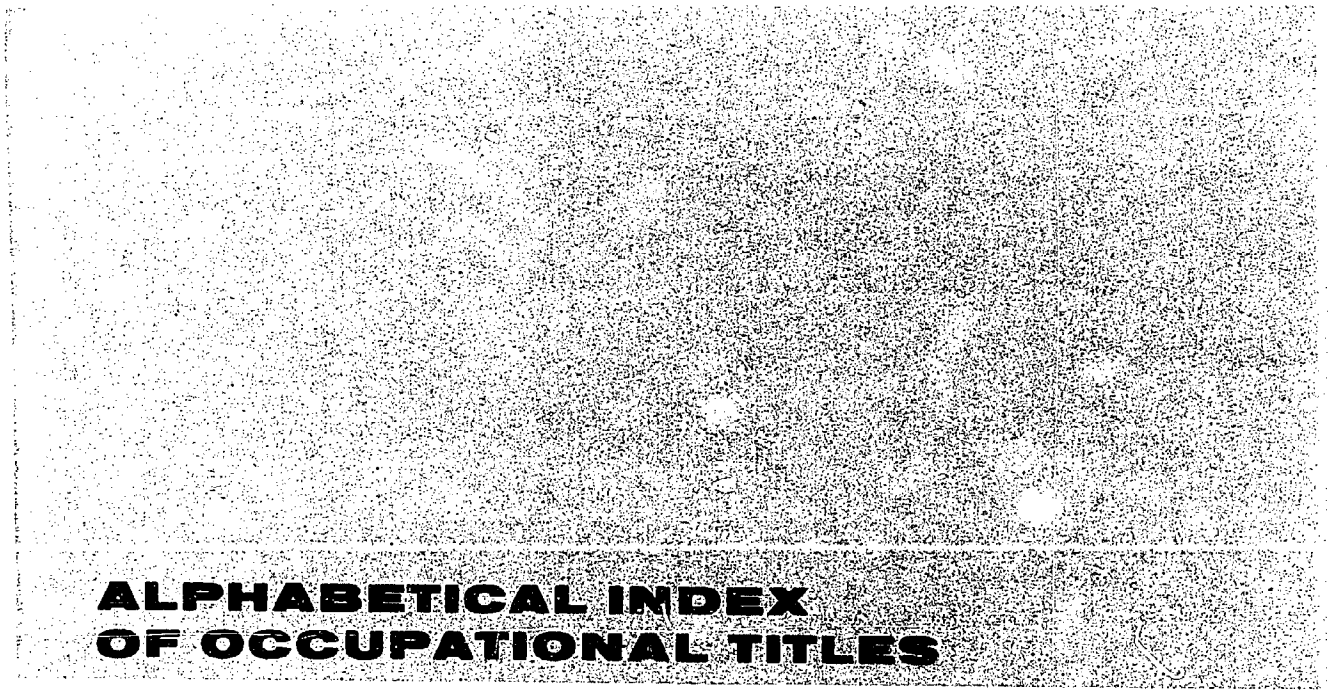
Fumes—Smoky or vaporous exhalations, usually odorous, thrown off as the result of combustion or chemical reaction.

Odors—Noxious smells, either toxic or nontoxic.

Toxic Conditions—Exposure to toxic dust, fumes, gases, vapors, mists, or liquids which cause general or localized disabling conditions as a result of inhalation or action on the skin.

Dust—Air filled with small particles of any kind, such as textile dust, flour, wood, leather, feathers, and inorganic dust, including silica and asbestos, which make the workplace unpleasant or are the source of occupational diseases.

Poor Ventilation—Insufficient movement of air causing a feeling of suffocation; or exposure to drafts.



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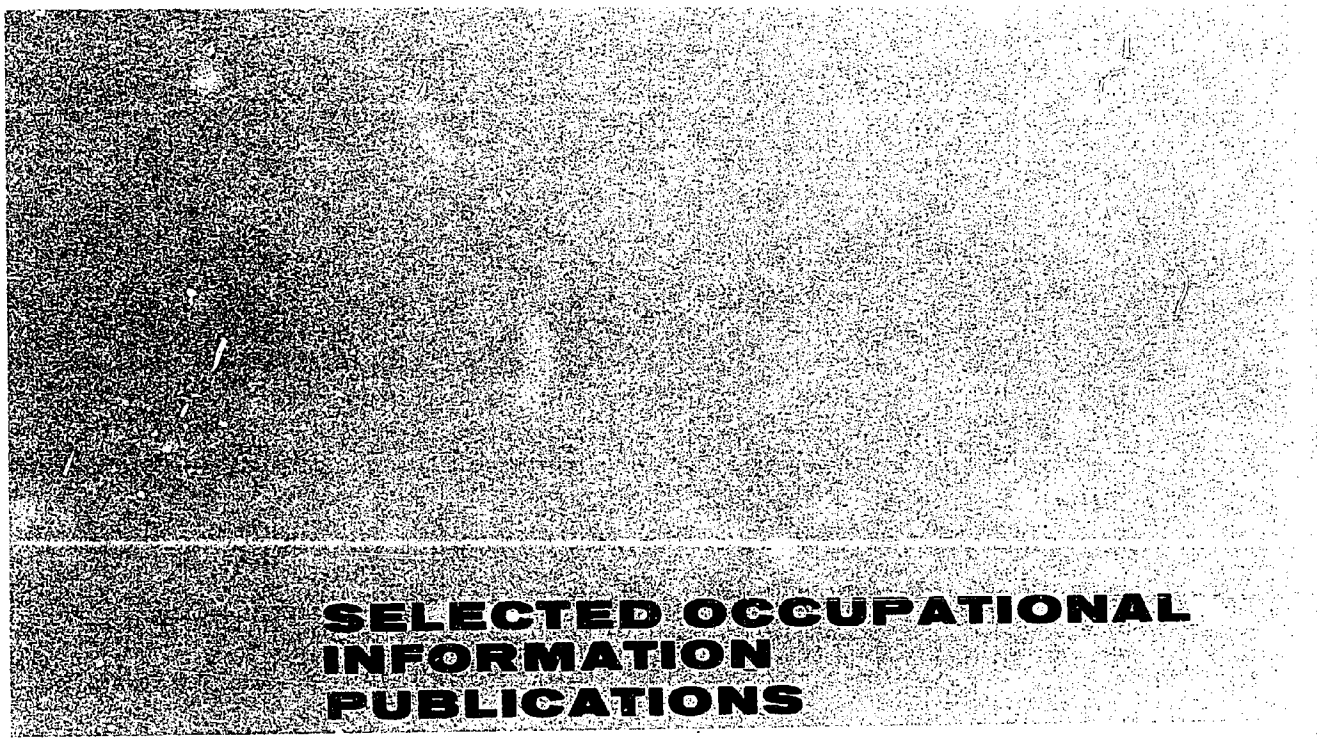

SELECTED OCCUPATIONAL INFORMATION PUBLICATIONS

Publications may be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Remittance in the form of check or money order payable to the Superintendent of Documents must accompany all orders. Do not send postage stamps.

1. DICTIONARY OF OCCUPATIONAL TITLES, Third Edition, in two volumes. Volume I (1965, 809 pp., $5.00) lists in alphabetical order over 35,000 job titles in the American economy. Provides definitions for almost 22,000 individual occupations.

   Volume II (1965, 656 pp., $4.25) presents the occupational classification structure of the U.S. Training and Employment Service. The structure consists of two arrangements of jobs. The first arrangement groups jobs according to a combination of work field, purpose, material, product, subject matter, generic term, and/or industry. The second arrangement groups jobs according to abilities and traits required of workers. Also arranges jobs according to industry.

   SELECTED CHARACTERISTICS OF OCCUPATIONS (PHYSICAL DEMANDS, WORKING CONDITIONS, TRAINING TIME), A SUPPLEMENT TO THE DICTIONARY OF OCCUPATIONAL TITLES, Third Edition. (1966, 280 pp., $2.75.) Lists individual physical demands, working conditions, and training time data for all jobs defined in the Dictionary. The information provides additional source material for determining job relationships in such activities as vocational counseling, personnel and manpower activities, training, rehabilitation, and placement.

   SELECTED CHARACTERISTICS OF OCCUPATIONS BY WORKER TRAITS AND PHYSICAL STRENGTH, SUPPLEMENT 2 TO THE DICTIONARY OF OCCUPATIONAL TITLES, Third Edition. (1968. $1.25). A rearrangement of the data contained in the first supplement. The data is presented by the

worker trait groups contained in Volume II of the Dictionary. They are then subgrouped by level of strength required. The supplement will be useful in counseling and placement activities, particularly in determining utilization, transfer, and placement possibilities for handicapped and aged workers.

2. GUIDE FOR ANALYZING JOBS, ANALYST'S WORKBOOK (Reprinted in 1966, 40 pp., $0.25). A companion, pocket-sized workbook to the TRAINING AND REFERENCE MANUAL FOR JOB ANALYSIS. Presents basic techniques of job analysis in outline form and provides an explanation of each job analysis component.

3. HEALTH CAREERS GUIDEBOOK (1965, $1.50). Written and designed to appeal to young people who are interested in planning a career in the health field. Describes more than 200 jobs in this field and contains information about educational, training, and licensing requirements; job prospects; salaries and working conditions; personal qualifications required; and sources of additional information.

4. JOB GUIDE FOR YOUNG WORKERS (1968). Presents highlight information on entry jobs or fields of work frequently held by young people leaving high school. Provides information on employment prospects, qualifications for jobs, usual duties, characteristics of the jobs, and how and where jobs are obtained. Also directs the young jobseeker to Federal and State agencies which can provide job information and counseling. Includes selected readings and some tips on how to get a job.

5. OCCUPATIONS IN ELECTRONIC COMPUTING SYSTEMS (1965, 72 pp., $0.30). Describes 23 different occupations peculiar to the electronic computing field. Gives the education, training, and characteristics required of the worker by the job, and lists the physical activities and environmental conditions usually encountered. Also has a glossary of technical terms, a bibliography, and a listing of organizations, colleges, and universities where additional information about electronic computing systems may be obtained.

6. OCCUPATIONS IN THE FIELD OF LIBRARY SCIENCE (1966, 57 pp., $0.30). Presents descriptive information about 22 occupations involved in library work, including education, training, experience, and the worker traits required.

7. OCCUPATIONS IN THE CARE AND REHABILITATION OF THE MENTALLY RETARDED (1966, 76 pp., $0.35). Discusses the problems peculiar to the care and rehabilitation of those afflicted with mental retardation and describes 27 occupations involved in such care and rehabilitation. Illustrated.

8. TECHNICAL REPORT ON OCCUPATIONS IN NUMERICALLY CONTROLLED METAL-CUTTING MACHINING (1968, 91 pp., $0.45). Describes 14 occupations in metal-cutting machining and the changes which have been brought about by the introduction of numerical control processes.

9. TECHNOLOGICAL CHANGES IN COMPOSING ROOM AND BINDERY PROCESSES IN THE PRINTING AND PUBLISHING INDUSTRY (1964, 50 pp.). A single copy, in limited supply, is available upon request from the U.S. Training and Employment Service, Manpower Administration, U.S. Department of Labor, Washington, D.C. 20210. Presents a preliminary picture of occupational and staffing changes brought about in composing room and bindery processes as a result of the introduction of automated equipment or technological innovations. It is a limited study, covering eight plants in a single geographical area, and, therefore, not necessarily representative of the industry as a whole.

10. TRAINING AND REFERENCE MANUAL FOR JOB ANALYSIS (Interim Revision, 1965, 91 pp., $0.60). An operational and reference text that presents the principles and practices for obtaining information about jobs.

11. TRAINING MANUAL FOR THE DICTIONARY OF OCCUPATIONAL TITLES, Third Edition. Part A, Instructor's Guide (1965, 23 pp., $0.25). Provides a guide to instructors for initiating and conducting the self-training program covering the Dictionary.
Part B, Trainee's Workbook (1965, 323 pp., $1.75). A self-instructional text, presented in the form of a linear program, covering the contents, structure, arrangement, and use of the Dictionary.

Other occupational information publications prepared by the U.S. Training and Employment Service are listed in a booklet titled BUREAU OF EMPLOYMENT SECURITY PUBLICATIONS, Section III, "Employment Service Publications." This booklet may be obtained without cost from the nearest local office of your State employment security agency or by writing to the U.S. Training and Employment Service, Manpower Administration, U.S. Department of Labor, Washington, D.C. 20210.

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